2012
LUMMI NATION
WATER QUALITY ASSESSMENT REPORT
JUNE 28, 1993 TO DECEMBER 31, 2012

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EXECUTIVE SUMMARY

The goals of the Lummi Nation Surface Water Quality Monitoring Program (Program) are to:

a) Document ambient water quality and water quality trends on the Lummi Indian Reservation (Reservation);
b) Evaluate regulatory compliance of waters flowing through and onto the Reservation, including compliance with Lummi Nation Surface Water Quality Standards; and
c) Support the development and implementation of water quality regulatory programs on the Reservation.

The purpose of this report is to:

a) Present the surface water quality data collected during the calendar year 2012;
b) Compare the 2012 results to data from the period of record;
c) Present interpretations of these data with respect to the Program goals; and
d) Provide the U.S. Environmental Protection Agency (EPA) documentation required pursuant to the *Final Guidance of Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act* (EPA 2006).

The Reservation consists of approximately 12,500 acres of uplands, 38 miles of marine shoreline, and 7,000 acres of tidelands. Water quality on the Reservation is complex for several reasons. It is located in the estuaries of the Lummi River and the Nooksack River where marine and fresh water interact; the water column may have varying degrees of salinity-based stratification. In addition, water can flow upstream, downstream, or be stagnant at many of the sampling sites depending on the tides and weather conditions. Upland sites become saline or dry during the summer months as the dry season progresses. Once the wet season begins during October or November, upland flow increases, diluting many of the saline monitoring sites with freshwater.

The water quality parameters measured at the monitoring sites during 2012 generally followed the trends of 2003 through 2011 with elevated bacteria levels, higher temperatures, and lower dissolved oxygen levels compared to the Lummi Nation Water Quality Standards (LWRD 2008a). Fecal coliform bacteria levels in the mainstem of the Nooksack River at the Reservation border (SW118) were increased during 2012 compared to the trends of the 2008 through 2011 period. Data show fecal coliform bacteria levels at Site SW118 increased in 2012 above the 90th percentile and the Total Maximum Daily Load (TMDL) target of a geometric mean of 39 coliform forming units per 100 milliliters established for the lower Nooksack River (Ecology 2000 and 2002). Site SW118 did achieve the geometric mean established for the Nooksack River by the Lummi Nation Water Quality Standards, however, the geometric mean was increased compared to data obtained in 2011.

The marine waters of Lummi Bay and the Sandy Point Marina continue to have relatively good quality, while the surface waters within the Lummi River and Jordan Creek watershed continue to have the poorest water quality of the sites sampled on the Reservation. Sampling of the Nooksack River indicated variable water quality with elevated fecal coliform bacteria findings during 2012 that are a cause of concern. The 90^{th} percentile and TMDL target established for the river were not achieved compared to the 2008 through 2011 period and corresponds to declining water quality in Portage Bay during 2012. The increased levels of fecal coliform bacteria in the Nooksack River and in Portage Bay are an indication that the technical assistance and enforcement actions in the Nooksack River Basin which were helping improve water quality are not adequate to protect water quality in the long term. The continuing poor water quality in the Lummi River and tributaries to Lummi Bay, particularly with respect to increased fecal coliform bacteria contamination, is a major concern due to the potential for new closures of important tribal shellfish beds. The members of the Lummi Nation use these shellfish beds for ceremonial, subsistence, and commercial purposes.

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1. INTRODUCTION

The purpose of this introductory section is to present the goals of the Lummi Nation Surface and Ground Water Quality Monitoring Program (Program), identify Program staff changes during the reporting period, summarize Program improvements during 2012, and provide an outline of the report contents.

1.1. Purpose Statement

The Program was initiated in June 1993 to establish the ambient conditions of the Lummi Indian Reservation (Reservation) surface waters, which are a component of the Lummi Nation Waters. This information is used to evaluate regulatory compliance of waters flowing through and onto the Reservation including compliance with Lummi Nation Surface Water Quality Standards (LWRD 2008a); to identify and track water quality trends; and to support the development and implementation of water quality regulatory programs on the Reservation.

The purpose of this report is to describe the Lummi Nation Water Quality Program and to present the surface water quality data collected during calendar year 2012; compare the 2012 results to data from the period of record, and present interpretations of these data with respect to the Program goals. This report is also intended to provide the U.S. Environmental Protection Agency (EPA) documentation required pursuant to the *Final Guidance of Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act* (EPA 2006).

This report contains data collected pursuant to associated work plans and grant agreements between the Lummi Nation and the EPA. The data collected between January 1, 2012 and December 31, 2012 are presented in tabular form in Appendix A. These data were exported to EPA's Water Quality Exchange Network (WQX) on February 1, 2013. The data collected over the period of record were exported to WQX on March 9, 2015.

1.2. Program Staff Changes

Although the Water Resources Manager of the Lummi Water Resources Division (LWRD) of the Lummi Natural Resources Department (LNR) is responsible for the overall success of the Program, operation of the Program is delegated to the Water Resources Specialist. In the past, the Water Resources Specialist supervised a Water Resources Technician, who performed most of the water quality sampling and data entry. The Water Resources Specialist left LNR during the spring of 2005 after 12 years of service, including the initiation and development of the Program. The Water Resources Technician also resigned during the spring of 2005 after 7 years of service. These positions were filled during the spring and early summer of 2005, but both positions were again vacated during July and August 2006. The Water Resources Specialist position was refilled in October 2006 and the Water Resources Technician position was filled in February 2007. As these two staff members are the primary staff responsible for program implementation, and several months were required each time to select, hire, and train the replacements, substantially fewer water quality samples were collected during 2005, 2006, and 2007 relative to previous and subsequent years.

During the winter of 2008, a GIS/Water Resources Technician III was hired to assist with water quality sampling. Training and familiarization with the program continued during the first half of 2009. During the second half of 2009, the Program stabilized and the frequency of sampling approached the schedule described in the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010). During the spring of 2008, the Water Resources Specialist position was again vacated and the position was not re-filled until October 2008. During this period, the Water Resources Technician III was promoted to Water Resource Specialist I and assigned to lead the field data collection elements of the Program. From October 2008 through October 2011, the Program consisted of a Water Resources Specialist I and a GIS/Water Resources Technician III with additional support provided by a Water Resources Specialist II, including completion of the annual Program Water Quality Assessment Reports. In early November 2011 the Water Resources Specialist II resigned and the Water Resources Specialist I became the staff member responsible for leading field collection efforts and for completion of annual Program Water Quality Assessment Reports. In December 2011 a Water Resources Technician III was hired to assist the Water Resources Specialist I and GIS/Water Resources Technician III with field data collection.

1.3. Program Improvements

When the Program was initiated in 1993, the collected data were recorded in field books and lab reports and then transcribed into computerized spreadsheets for analysis. The need to develop a database to manage the collected data was recognized by 1996, but the staff and financial resources needed to develop the database were not available. As more and more data were collected, the need to develop a database became increasingly urgent. Starting in 2005, an effort was initiated to develop improved data storage, management, and analysis capabilities. As part of this database development effort, standardized field data collection forms were also developed to ensure that all of the required data were collected and to facilitate the input of collected data into the database.

The Water Quality Monitoring Database development was largely completed during 2006 (LWRD 2011a) and was initially populated with the water quality data from 2006. Because the historical data could not be directly converted from the spreadsheets into the new database structure, a contractor was hired during 2007 and 2008 to enter all of the surface water quality data for the remainder of the period from 1993 through October 2008 into the new database. This task was completed in October 2008. Lummi Natural Resources Department (LNR) staff have entered all subsequent data into the database. In late October 2011, a newly developed database interface (front end) was launched that allows users to input 'real-time' data directly into the existing Water Quality Monitoring Database (back end) while the user is still on-site in the field. The new front end interface is optimized for ease-of-use on touch-screen devices and connects to the Lummi Nation servers via the 'Citrix Receiver' application using a 3G internet connection. The ability to remotely enter data into the database eliminates the need to laboriously transcribe data from field sheets at a later date, and allows some metadata (such as sample times and dates) to be automatically populated during the 'real-time' data entry process. This front-end interface, which utilizes an Apple iPad device provides significant time savings, reduces the potential for transcription errors, and makes the results available for use immediately following collection in the field. Paper data collection forms are still carried as a back-up system in case of internet connection loss or if failure of the data entry device occurs during a sampling run.

In 2010, with the addition of continuous water temperature data collection at selected sites throughout the Reservation, it was determined that the Water Quality Monitoring Database, which was not initially designed to manage continuously measured data, would not be able to store continuous monitoring datasets. During 2010, the Lummi Continuous Data Management System Database (LNR 2010b) was developed to assist with data management specifically for continuous datasets and has been used to manage continuous temperature data collected from ten surface water sites throughout the Reservation in 2012.

In addition to the databases developed by LNR staff members, a data analysis tool developed by Utah State University (USU) as part of the WRIA 1 Watershed Management Project (http://wria1project.whatcomcounty.org) was available in 2006. The Lummi Water Quality Monitoring Database can export data in a format compatible with the USU data analysis tool, the EPA Water Quality Exchange Network (WQX), or the Excel spreadsheet program. The Lummi Water Quality Monitoring and Lummi Continuous Data Management System databases are also able to perform limited analyses of the data. The graphical presentation in this summary report includes products that originate directly or indirectly from these two databases.

Efforts to make the Lummi Nation Water Quality Monitoring Program more accessible to the general public included the development of a LNR website during 2010. The most recent water quality assessment report from 2011, the Quality Assurance Program Plan Version 4.0, user guides for the databases, and other documents are posted on the website (http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=56).

1.4. Report Overview

This report is organized into the following sections.

- Section 1 is this introduction.
- Section 2 is a description of the Lummi Nation Waters and the Lummi Nation’s Water Resources Management Program.
- Section 3 is a description of the surface and ground water quality monitoring objectives.
- Section 4 is a description of the Lummi Nation’s surface and ground water quality assessment methods.
- Section 5 is a summary of the Lummi Nation Surface Water Quality Standards.
- Section 6 presents a comparison of the results from 2012 and the period of record to the Lummi Nation Surface Water Quality Standards and identifies trends in key water quality parameters at representative sites.

- Section 7 is a discussion of the water quality sampling results.
- Section 8 is a summary and conclusion section.
- Section 9 is a list of references cited in this report.

Appendix A presents the 2012 surface water quality data in tabular form. As noted above, these data were exported to the EPA Water Quality Exchange Network (WQX) on February 1, 2013.

2. LUMMI NATION WATERS

The purpose of this section of the report is to describe the Lummi Indian Reservation location, Lummi Nation Water Resources Management Program, and provide an overview of the Lummi Nation Waters.

2.1.Lummi Indian Reservation

The Lummi Indian Reservation (Reservation) is located in the northwest corner of Washington State (Figure 2.1). The Lummi Nation is a federally recognized Indian tribe with the Lummi Indian Business Council (LIBC) as its governing body. There are more than 4,500 enrolled members of the Lummi Nation. The Reservation is located along the western boundary of Whatcom County, Washington adjacent to Georgia Strait and Puget Sound. The Reservation includes portions of the Nooksack River and Lummi River watersheds, which drain into Bellingham Bay and Lummi Bay respectively. The Nooksack River drains a watershed of approximately 809 square miles, enters the Reservation near the mouth of the river, and discharges to Bellingham Bay (and partially to Lummi Bay during high flows). The Reservation is located approximately 8 miles west of Bellingham, 90 miles north of Seattle, and 60 miles south of Vancouver, British Columbia, Canada. The 2012 Lummi Nation Atlas reported that the total Reservation population was 2,650 people.

The Reservation is comprised of about 12,500 acres of upland and 7,000 acres of tidelands. Approximately 38 miles of highly productive marine shoreline surround the Reservation on all but the north and northeast borders. The Reservation includes the Nooksack River and Lummi River deltas, tidelands, forested uplands, Portage Island, and the Sandy Point Peninsula. Both the Nooksack River and Lummi River watersheds are under environmental pressures from rapid regional growth. The Lummi Nation has also entered a period of economic development under self-governance. Much of the high-density development to date has occurred along the marine shoreline. Construction of a new Tribal Administration Building began during 2011 and was completed June 2013, in addition to several other new residential and municipal development projects throughout the Reservation. Growth on and near the Reservation requires that the Nation's core environmental program prioritize the development of a regulatory infrastructure that is technically sound, legally defensible, and administratively efficient. This regulatory infrastructure needs to allow for growth while protecting tribal resources and the Reservation environment. This infrastructure will support both the tribal goals and EPA's policy of tribal self-governance and recognition of sovereignty.

Lummi Indian Business Council resolutions 90-88 and 92-43 directed the Water Resources Division of the Lummi Natural Resources Department to develop a comprehensive water resources management program that ensures that the planning and development of Reservation water and land resources are safeguarded against surface and ground water degradation. Reliable information on the surface and ground water quality of the Reservation is required in order to effectively manage these resources.

The EPA and other federal agencies have previously supported the Nation's assessment of priority water resource needs and the identification of unmet needs. Environmental planning intended to protect the Nation's water resources has included the development and updating of a Wellhead Protection Program (LWRD 2011c), a Storm Water Management Program (LWRD 2011b), a Wetland Management Program (LWRD 2000), a Nonpoint Source Management Program (LWRD 2001, LWRD 2002), and Water Quality Standards for Reservation Surface Waters (LWRD 2008a). These programs are components of the Lummi Nation Comprehensive Water Resources Management Program (CWRMP). Important milestones in the program development effort include the adoption of the Lummi Nation Water Resources Protection Code (Title 17 of the Lummi Code of Laws) during January 2004, the adoption of surface water quality standards in August 2007, and the adoption of four Lummi Administrative Regulations in July 2010. The tribal water quality standards were approved by the EPA in September 2008.

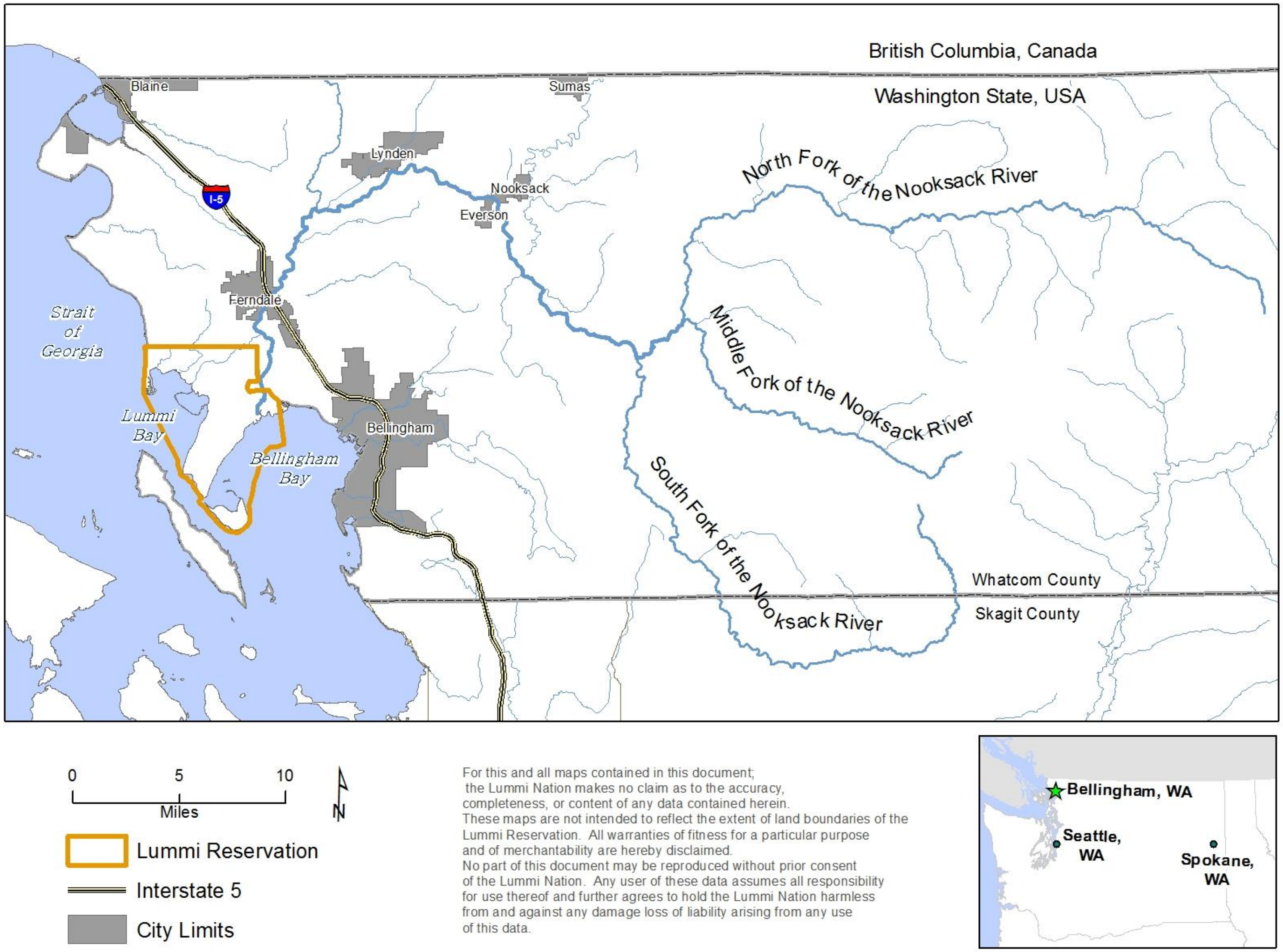

Figure 2.1 Regional Location of the Lummi Indian Reservation

2.2.Lummi Nation Waters

Lummi Nation Waters are all fresh and marine waters that originate or flow in, into, or through the Reservation, or that are stored on the Reservation, whether found on the surface of the earth or underground, and all Lummi Nation tribal reserved water rights (Lummi Code of Laws [LCL] 17.09).

2.2.1. Surface Water

The Lummi Nation is the largest fishing tribe in Puget Sound and has relied on water resources since time immemorial for ceremonial, subsistence, and commercial purposes. There are approximately 38 miles of marine shoreline surrounding most of the Reservation (except portions of the east boundary and the northern boundary). The surrounding tidelands are in the Strait of Georgia, Hale Passage, Lummi Bay, Portage Bay, and Bellingham Bay. In addition to marine waters, there are approximately 24.4 miles of rivers, streams, sloughs, and drainages on the Reservation including the multiple distributary channels of the Nooksack River delta. There are no lakes on the Reservation, but there are approximately 13 ponds. Finfish and shellfish spawn, incubate, and grow within and adjacent to Lummi Nation Waters (LNR 2010a). The Lummi Nation also operates one shellfish and two salmon hatcheries on the Reservation.

Eighteen (18) watersheds are found on the Lummi Reservation. Reservation watersheds were delineated by the Lummi Water Resources Division as “A” through “T” (Figure 2.2) and vary in size from 134 acres up to 4,100 acres (LNR 2010c). The Nooksack River discharges to Reservation tidelands, but most of the approximately 809 square mile Nooksack River watershed is upstream of the Reservation. The 18 watersheds are aggregated into two primary drainage areas: Lummi Bay and Bellingham Bay (Figure 2.3). The Lummi Bay watershed is comprised of nine watersheds: C, H, I, K, L, O, P, Q, and R. It is noted that a portion of Watershed R discharges to Georgia Strait and that a portion of Watershed C discharges to Hale Passage. The Bellingham Bay watershed is also comprised of nine watersheds: A, B, D, E, F, G, J, S, and T. It is noted that all of Watershed A discharges to Hale Passage and that a portion of Watershed D also discharges to Hale Passage. As shown in Table 2.1, 11 of the 18 watersheds are completely within the Reservation boundary. Approximately 0.3 percent of the Nooksack River watershed (Watershed S) is on the Reservation.

There are 11 defined rivers, streams, sloughs, and drainages in the Lummi Bay and Bellingham Bay watersheds. Streams on the Reservation are classified as either Category 1 or Category 2 streams (LCL Title 17.06.080). Category 1 streams are all streams that flow year-round during years of normal rainfall or are used by juvenile or adult salmonids. Category 2 streams are all streams that are intermittent or ephemeral during years of normal rainfall and are not used by juvenile or adult salmonids. Of the eleven defined rivers, streams, sloughs, and drainages, there are six Category 1 streams and five Category 2 streams on the Reservation. All other agricultural ditches and unnamed drainages are classified as Category 2 streams. As shown in Table 2.2, there are approximately 24.4 miles of streams, rivers, sloughs, and drainages on the Reservation. Jordan Creek, Lummi River, Smuggler’s Slough, Slater Slough, Schell Creek, Onion Creek, and Seapond Creek are included in the

Lummi Bay watershed. The Bellingham Bay watershed is comprised of the Nooksack River, Kwina Slough, Lummi Shore Road streams, and Portage Island streams. Five streams, rivers, sloughs, and drainages are completely within the boundaries of the Reservation.

Prior to 1860, the Nooksack River discharged to Lummi Bay rather than to Bellingham Bay (Deardorff 1992, WSDC 1960). The river flow was redirected to Bellingham Bay at that time and currently the Lummi River only receives water from the Nooksack River when the Nooksack River flows exceed approximately 9,600 cubic feet per second (cfs). The Lummi River currently drains much of the area west of the Nooksack River in the vicinity of Ferndale, Washington. The Nooksack River drains most of western Whatcom County, including most of the forested uplands and the developed lowlands.

The Nooksack River flow is comprised of groundwater and precipitation throughout the year supplemented by glacial melt and snowmelt from Mount Baker and adjacent peaks of the Cascade Mountain range during the summer months. The Nooksack River supports several important species of salmon and other aquatic life. The Nooksack River delta is part of the Reservation and is part of an important marine wetland-estuary complex. There are water quality and water quantity challenges in the Nooksack watershed due to land development and agriculture. Whatcom County, which includes all of the lowlands in the Nooksack River watershed, had 167 dairy operations in 2005. All or portions of approximately 220 acres of tribal shellfish beds in Portage Bay were closed to commercial harvest over the November 1996 to May 2006 period due to bacterial contamination attributed to poor dairy nutrient management practices in the Nooksack River watershed (DOH 1997, Ecology 2000).

Nearly all of the water bodies in the Lummi River and Nooksack River floodplains are exposed to marine influences, which include the presence of saline water, salinity-based-stratification (stratification), and upstream flow during high tide. Most of the water quality sample sites are tidally influenced (water level and/or salinity) and have variable water column profiles (e.g., stratified or well-mixed) and salinities. In addition, upland sampling sites become saline or dry during the summer months as the dry season progresses. Once the wet season begins during October or November, flow from the uplands increase, diluting many of the saline monitoring sites with freshwater.

The 1999 comprehensive wetland inventory on the Lummi Reservation (LWRD 2000) indicated that approximately 43 percent (5,432 acres) of the Reservation upland areas are either wetlands or wetland complexes (Figure 2.4). Of these Reservation wetland areas, about 60 percent are located in the floodplains of the Lummi River and Nooksack River. Wetland complexes are areas where wetlands form a highly interspersed mosaic with upland hummocks. During the 1999 wetland inventory, boundaries were drawn around the outer edges of the mosaics and the entire areas labeled as “wetland complexes”. As a result, the estimated wetland area identified in the 1999 inventory generally represents more wetland area than actually exists. All wetland boundaries mapped during the comprehensive wetland inventory are general boundaries based on soil survey mapping and interpretation of color and infrared aerial photographs with some field verification. More accurate wetland boundaries are being delineated on the ground as needed for specific activities and as part of an overall effort to improve the spatial accuracy of the wetland Geographic Information

System (GIS) database. As of 2012, approximately 241 wetlands and 3,212 acres of wetland area have been evaluated as part of the 1999 wetland inventory update (LWRD 2013).

The majority of the estuarine wetlands of the Lummi and Nooksack rivers will be protected and functionally improved through the implementation of the Lummi Nation Wetland and Habitat Mitigation Bank. The mitigation bank is being developed in phases. Implementation of Phase 1A, which encompasses most of the Nooksack River estuary, began in 2011. Enhancement measures like invasive species control and under planting with conifers will improve the ecological functions of the estuary. The mitigation bank will be protected into perpetuity through a conservation easement and used to mitigate unavoidable impacts to habitat and wetlands on the Reservation. Wetland mitigation credits will also be available for purchase within the service area of the bank (LWRD 2008b).

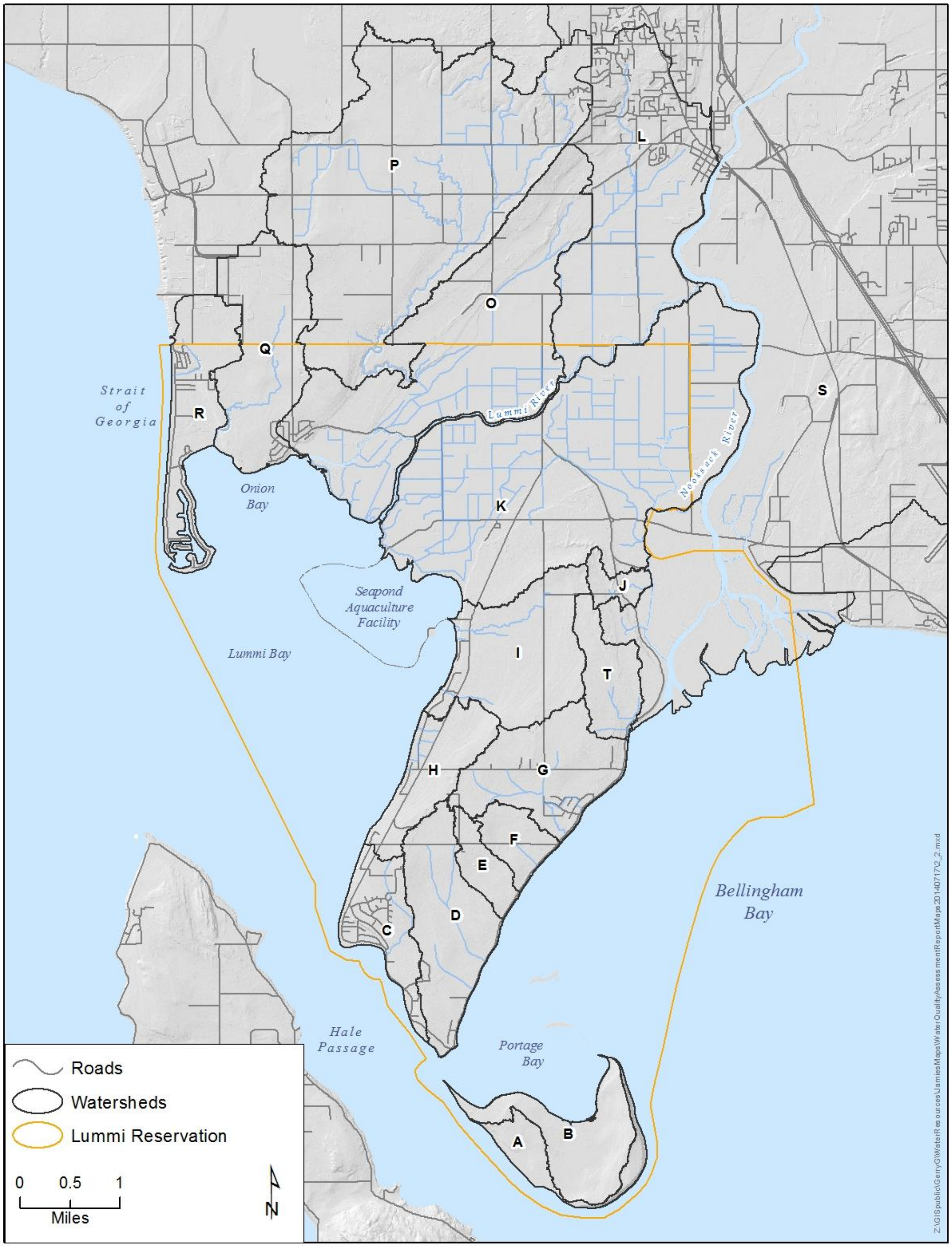

Figure 2.2 Lummi Nation Watersheds

Table 2.1 Acres of Watersheds On-Reservation and Off-Reservation

	Basin ID	Total Watershed Area (acres)	On-Reservation Watershed Area (acres)	Off-Reservation Watershed Area (acres)	On-Reservation Percent of Watershed
Lummi Bay Watershed	C	494	494	0	100
	H	549	549	0	100
	I	1,059	1,059	0	100
	K	4,091	3,354	737	82
	M	Combined with Watershed L			
	N	Combined with Watershed O			
	L	2,307	133	2,174	6
	O	2,747	1,552	1,195	57
	P	4,097	228	3,869	6
	Q	1,096	570	526	52
	R	722	531	191	74
Bellingham Bay Watershed	A	280	280	0	100
	B	617	617	0	100
	D	894	894	0	100
	E	218	218	0	100
	F	251	251	0	100
	G	883	883	0	100
	J	134	134	0	100
	S	518,033	1,296	516,737	0.3
	T	392	392	0	100

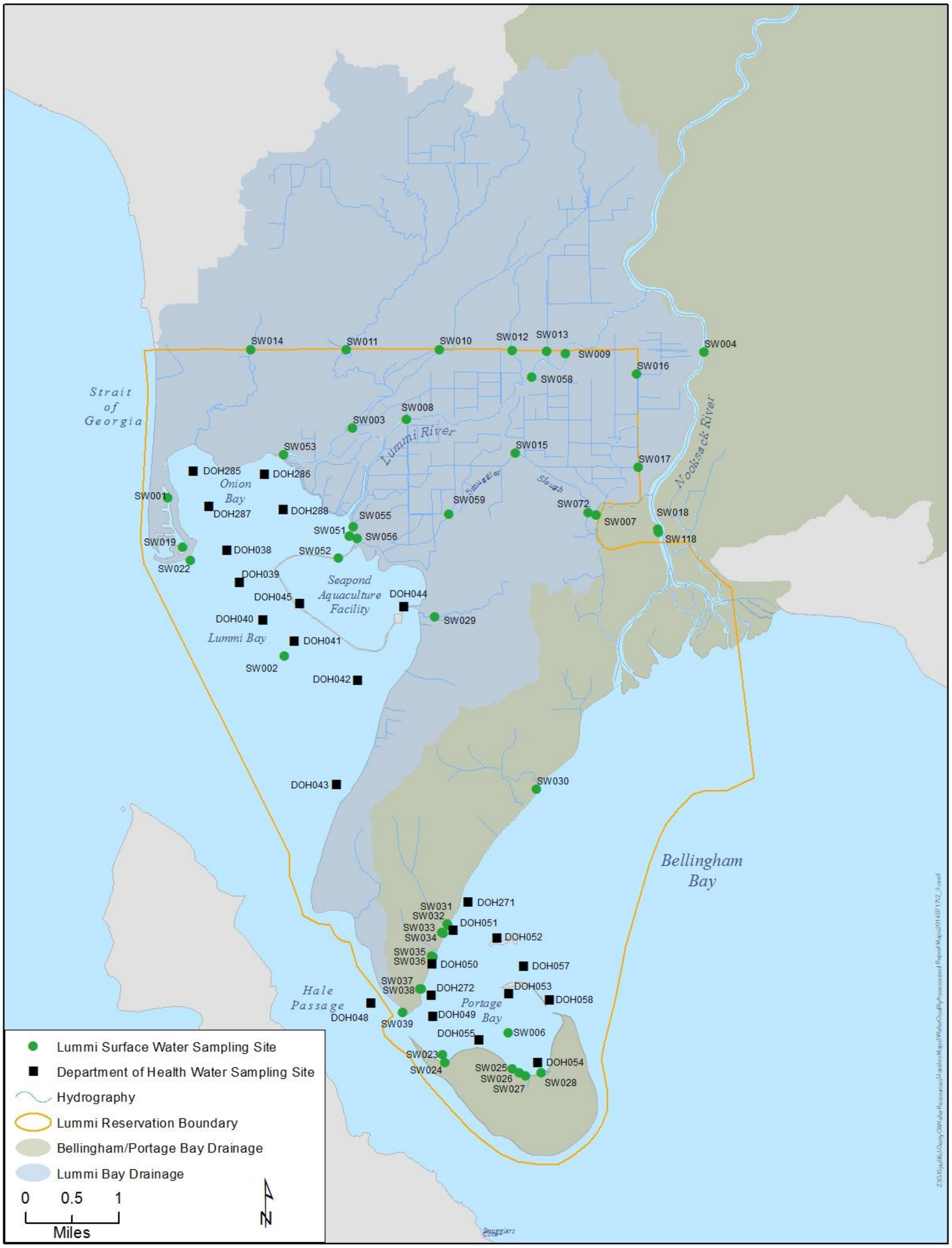

Figure 2.3 Lummi Bay and Bellingham Bay Drainage Areas

Table 2.2 River and Stream Miles On-Reservation and Off-Reservation

	River/ Stream	Stream Category	Total Stream/ River Miles	On-Reservation Stream/ River Miles	Off-Reservation Stream/ River Miles	On-Reservation Percent of Stream/ River Miles
Lummi Bay Watershed	Jordan Creek	1	6.6	2.1	4.5	32
	Lummi River	1	5.0	3.6	1.4	70
	Smuggler's Slough	1	3.9	3.9	0	100
	Slater Slough	2	1.3	1.3	0	100
	Schell Creek	1	4.1	0.4	3.7	10
	Onion Creek	2	2.2	1.8	0.4	81
	Seapond Creek	2	1.7	1.7	0	100
Bellingham Bay Watershed	Nooksack River	1	150	5.1*	144.9	3
	Kwina Slough	1	2.3	2.1	0.2	91
	Lummi Shore Road Streams	2	2.3	2.3	0	100
	Portage Island Streams	2	0.1	0.1	0	100

* Includes all distributary channel lengths in the Nooksack River delta.

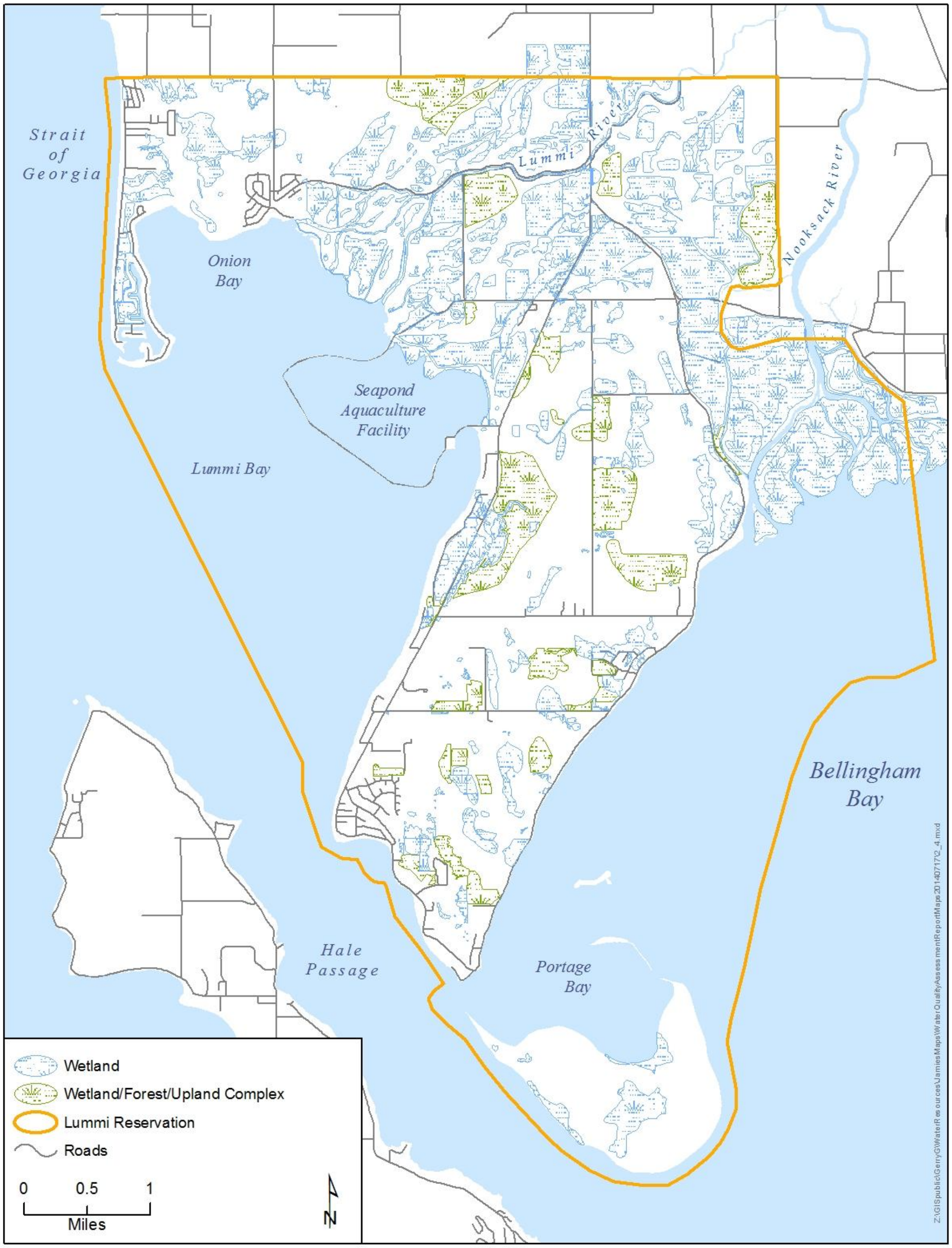

Figure 2.4 Lummi Nation Wetland Areas

2.2.2. Groundwater

Two separate potable groundwater systems occur on the Reservation. One system is located in the northern upland area. This northern system flows onto the Reservation from the north and drains to the west, south, and east (Aspect Consulting 2009). The second potable groundwater system is located in the southern upland area of the Reservation (Lummi Peninsula) and is completely contained within the Reservation boundaries (LWRD 1997, Aspect Consulting 2003). The floodplain of the Lummi and Nooksack rivers, which contains a surface aquifer that is saline (Cline 1974), separates the two potable groundwater systems (Figure 2.5). A third potable groundwater system may exist on Portage Island, but information on the water quality and the potential yield of this system is limited and inconclusive. Over 95 percent of the potable water used by Reservation residents is pumped from the Reservation aquifers. Because of the proximity to marine waters and the local geology, the aquifers on the Reservation are subject to both horizontal and vertical saltwater intrusion if wells are over-pumped (LWRD 1997).

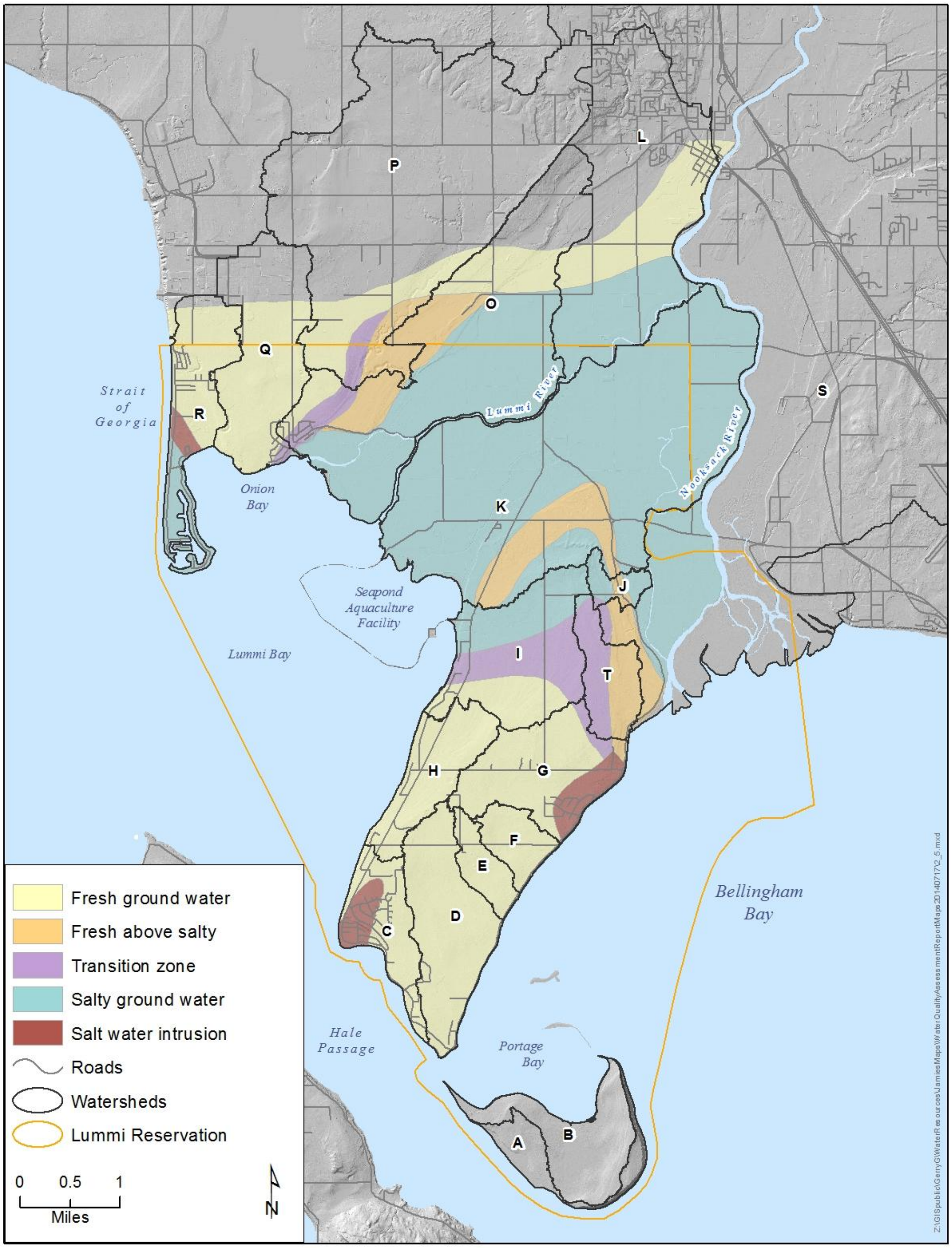

Figure 2.5 Lummi Reservation Groundwater Characteristics

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3. WATER QUALITY MONITORING OBJECTIVES

The purpose of this section is to describe the goals of the Lummi Water Resources Division (LWRD), the long-term water quality monitoring objectives, the Surface Water Quality Monitoring Program objectives, and the Groundwater Quality Monitoring Program objectives.

3.1. Lummi Water Resources Division Goals

The LWRD is responsible for protecting, restoring, and managing Lummi Nation water resources, including the Reservation shorelines, in accordance with the policies, priorities, and guidelines of the Lummi Nation. The overall goal of the LWRD is to protect the treaty rights to water of sufficient quantity and quality to support both the purposes of the Reservation as a permanent, economically viable homeland for the Lummi People, and to support a sustainable harvestable surplus of salmon and shellfish.

3.2. Long-Term Water Quality Monitoring Objectives

The Lummi Nation Surface and Ground Water Quality Monitoring Program (Program) has been ongoing since 1993. The goal of the Program is threefold: (1) to establish the baseline conditions of surface and ground waters on and flowing through and onto the Reservation, (2) to use this information to evaluate regulatory compliance of waters flowing through and onto the Reservation, and (3) to support the development and implementation of a water quality regulatory program on the Reservation.

The water quality monitoring objectives to help achieve the overall LWRD and the Program goals include:

1. Monitor surface and ground water quality at representative locations and at frequencies sufficient to establish baseline conditions of Lummi Nation Waters.
2. Monitor surface waters for compliance with the Lummi Nation surface water quality standards to support all beneficial uses, including public health and public enjoyment; the propagation, protection, and restoration of finfish, shellfish, wildlife, and their habitats; and the protection of the surface waters of the Lummi Indian Reservation as cultural, economic, and spiritual resources of the Lummi People.
3. Identify and evaluate on- and off-Reservation sources of fecal coliform bacteria contributions to shellfish harvest areas.
4. Detect and document threats to water quality and associated beneficial uses to support compliance actions.
5. Protect groundwater supplies from saltwater intrusion and groundwater mining.

3.3.Surface Water Quality Monitoring Program Objectives

The Lummi Nation Nonpoint Source Assessment Report (LWRD 2001), the Lummi Nation Nonpoint Source Management Plan (LWRD 2002), and other documents developed as part of the Lummi Nation Comprehensive Water Resources Management Program (LWRD 1997, LWRD 1998, LWRD 2000) identify and locate the numerous threats to the quality of Lummi Nation Waters. These threats include both point and nonpoint sources of pollution associated with various land uses.

The purpose of the surface water quality monitoring component of the Program is to establish the baseline conditions of waters on and flowing onto the Reservation, to detect water quality problems, and to help identify the pollutant sources. Information from the Program is used to:

- Evaluate compliance of waters flowing onto and within the Reservation with water quality criteria,
- Evaluate fecal coliform bacteria contributions from on- and off-Reservation to shellfish harvest areas, and
- Support the development and implementation of a water quality regulatory program on the Reservation, including the implementation and revision of Lummi Nation Water Quality Standards.

3.4.Groundwater Quality Monitoring Program Objectives

The purpose of the groundwater quality monitoring component of the Program is to protect groundwater supplies from saltwater intrusion and groundwater mining. Groundwater resources on the Reservation are vulnerable to saltwater intrusion due to the proximity of marine waters and local geology (LWRD 1997). The majority of residential development to date has occurred along the marine shorelines of the Reservation placing the most vulnerable portion of aquifers at risk through direct pumping of groundwater near marine waters. Protection of groundwater is essential because:

- Over 95 percent of all water consumed on the Reservation comes from groundwater.
- An ample supply of good quality groundwater is needed to serve the purposes of the Reservation as a permanent and economically viable homeland for the Lummi People.

4. SURFACE AND GROUND WATER QUALITY ASSESSMENT METHODS

The purpose of this section of the report is to summarize the approach used to establish the ambient quality conditions of Reservation surface and ground water and to summarize the field data collection and laboratory analysis methodologies detailed in the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010).

4.1. Overview of Surface and Ground Water Assessment Design

The LWRD employs both a fixed station network and a targeted water sampling design. The fixed station network is used for baseline water quality monitoring and includes 43 routine surface water sample sites and 27 groundwater sample sites (LWRD 2010). In addition to these 43 surface water quality sample sites, the LWRD also collects samples at 12 Washington Department of Health (DOH) sample sites within Lummi Bay. As described in Section 4.2, the DOH collects water quality samples from Portage Bay. A targeted sampling design approach is used to improve understanding of specific issues that warrant further investigation (e.g., a reported or observed manure spill, a fish or waterfowl kill near a pesticide application site, questions regarding water quality impacts of an automobile recycling facility, storm water discharge from a construction site). For a targeted design approach, sites from the fixed station monitoring network and other sites generally located both up and downstream from the identified potential pollutant source are sampled.

4.2. Surface Water Field Data Collection and Laboratory Analysis

Since 1993, the Program has grown significantly in the number of sites sampled, the parameters measured, and the ability to manage and analyze collected data. Additional sites were added in the late 1990s to better evaluate the water quality impacts of Nooksack River water on Portage Bay and to better evaluate conditions in the Lummi Bay watershed. Figure 4.1 shows the locations of the current LWRD water quality sampling sites on the Reservation and the DOH sample sites in Lummi Bay and Portage Bay. Many of the 43 sample sites are located along the Reservation border, with the majority of the contributing watershed located off-Reservation. Several intermittent streams and storm water systems are sampled as part of the Program, along with the marine waters of Lummi Bay, Portage Bay, and the Sandy Point Marina.

In consultation with the Lummi Nation and under the Shellfish Consent Decree (Order Regarding Shellfish Sanitation, *United States v. Washington [Shellfish]*, Civil Number 9213, Subproceeding 89-3, Western District of Washington, 1994), the Washington Department of Health (DOH) is responsible to the federal Food and Drug Administration (FDA) to ensure that the National Shellfish Sanitation Program (NSSP) standards for certification of shellfish growing waters are met on the Reservation. In Lummi Bay 12 sites are sampled 6 times a year to provide logistical assistance to the DOH and also to assist with the achievement of Program goals. The DOH samples 12 sites in Portage Bay 6 times a year which assists in achievement of the Program goals. The LWRD also samples Portage Bay sites during flooding conditions in the Nooksack River when Tribal harvesters are gathering shellfish.

Thirty-two (32) of the 43 Lummi sampling sites are accessible from land. As summarized in Table 4.1 and Table 4.2, the LWRD staff measure a range of water quality variables each month. During the late summer to early-winter period, “first flush” sampling is conducted at many of these sample sites at variable intervals (weekly to monthly) based upon precipitation and runoff levels during the onset of the wet season.

The remaining 11 surface water quality sample sites are accessible by boat and are located on Portage Island, in southern Portage Bay, in Lummi Bay, and in the Sandy Point Marina. These sample sites are targeted for monthly sampling, but unsafe weather conditions have historically reduced the sampling frequency. A 26 foot aluminum sampling boat was put into service during 2007 to allow for safer sampling during poor weather conditions. The DOH sites in Lummi Bay are sampled at least six times each year in coordination with the DOH.

Information from all sample runs is used to establish baseline conditions, identify trends, and to evaluate compliance with water quality criteria. Some runs serve other purposes as well, for example, to determine if sources of fecal coliform bacteria in Portage Bay are local or from the Nooksack River watershed. To make this determination, the data collected by the DOH in and around Portage Bay are analyzed in conjunction with the data collected as part of the “Lummi Shore Road” (LSR) sample run. The LSR sample run is scheduled to occur within a few hours prior to the DOH sampling of Portage Bay. At the latest, the sampling occurs concurrently with DOH sampling of Portage Bay. Similar to the LSR sample run, the data collected as part of the “Bellingham Bay Watershed First Flush” sample run aid in determining fecal coliform bacteria sources impacting the Portage Bay shellfish beds.

The data collected during the “Floodplain East” (FPE) and “Floodplain West” (FPW) sample runs are used to establish baseline conditions for waters flowing onto the Reservation and waters contributing to Lummi Bay (all within the Lummi Reservation). Similar to the LSR sample run, the data collected as part of the FPE, FPW, and Lummi Bay First Flush sample runs aid in determining fecal coliform bacteria sources that may affect the Lummi Bay shellfish beds.

The collection of water quality data along the Reservation boundary allows for compliance evaluation of waters flowing onto the Reservation by comparing the sample results with water quality criteria. The sample site selection also allows surface water quality to be evaluated along the length of the Lummi River floodplain water bodies and their tributaries. This water quality information is used to help identify pollution sources in the Lummi Bay Watershed.

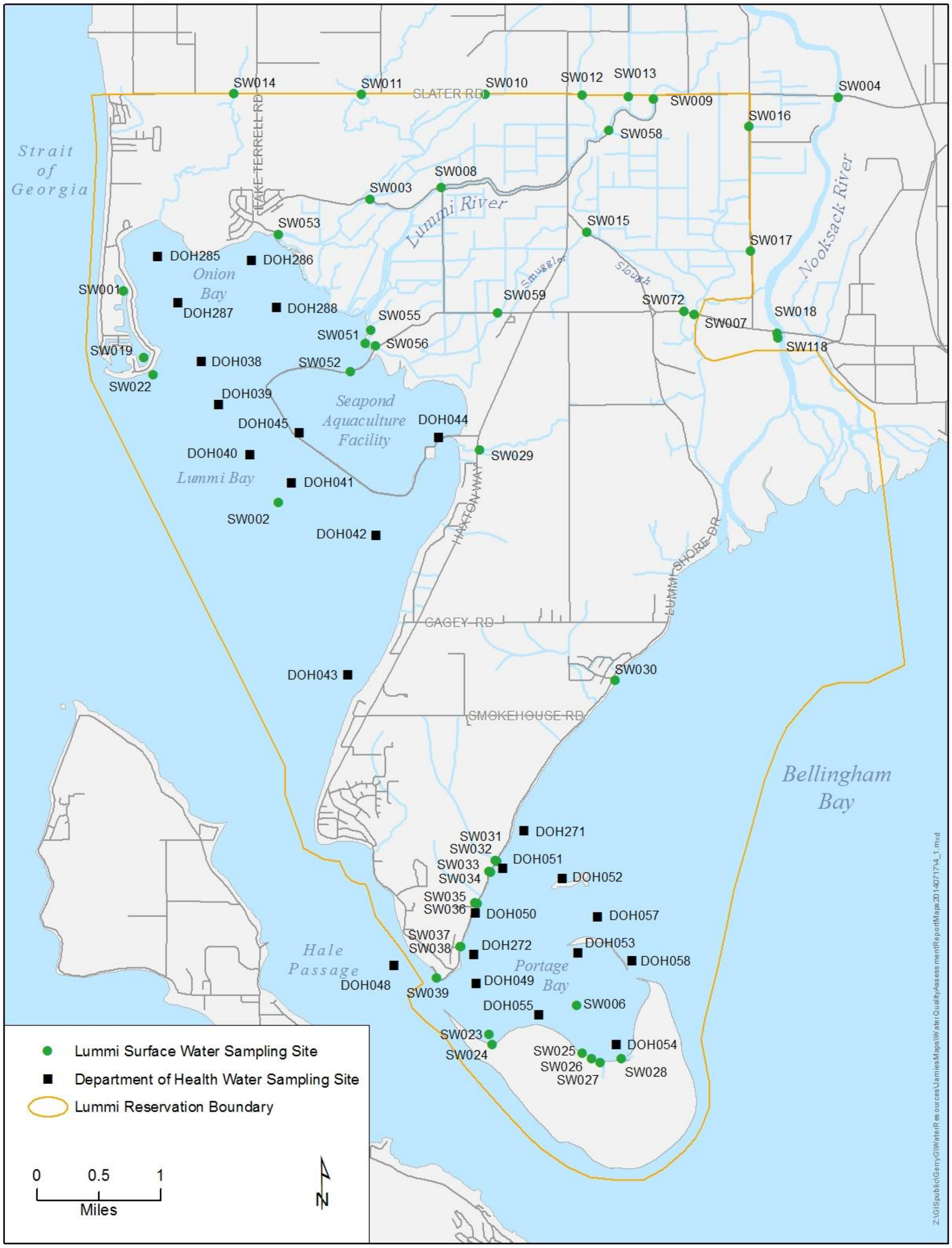

Figure 4.1 Lummi Surface Water Quality Sampling Sites and DOH Sample Sites

Data collected as part of the boat accessible sample run are used to establish baseline conditions of water quality in the Sandy Point Marina, Lummi Bay, Portage Bay, and the five Portage Island freshwater discharges to Portage Bay. These data can also help identify sources of pollution.

The "Lummi Bay DOH Support" sample run is conducted to provide information about water quality in Lummi Bay and assists in evaluating downstream impacts of elevated fecal coliform bacteria levels measured along the Reservation boundary.

The primary change in parameters measured over the Program period of record was the addition of new laboratory analyses. Bacteria sampling expanded in 2000 from often enumerating only one type of bacteria, fecal coliform or *Escherichia coli* (*E. coli*), to consistently enumerating both of these bacteria plus enterococci. In addition, starting in 1999 a suite of nutrient samples was collected approximately four times per year at five sites, and metals are sampled four times per year at two sites. When the Program was initiated in 1993, no nutrient or metal analyses were performed. At selected sites sampling is increased from the regular once-per-month to more frequent sampling during "first flush" events.

The conventional parameters measured over the Program period of record have remained constant, with the exception of pH and turbidity. The pH was not measured for many years (except at the contract laboratory for nutrient and metal samples) and, although total suspended solids are measured at the five sites that are sampled for nutrients, turbidity was not measured consistently prior to 2008. These parameters were not measured because of equipment problems coupled with the staff constraints described in Section 1.2. Starting in 2007, pH analysis was included for all sampling events, even if in some cases pH results were not obtained because of equipment malfunctions. Since March 2008, monthly turbidity measurements have been collected at the sample sites.

Table 4.1 summarizes the surface water quality monitoring sampling schedule for the following parameters measured during 2012 (see Appendix A for data): water temperature, air temperature, water depth, specific conductivity, salinity, dissolved oxygen, pH, turbidity, current flow direction, fecal coliform bacteria, *E. coli*, and enterococci. In accordance with the quality assurance plan for the laboratory, the contracted independent laboratory measures all bacteria from the same sample bottle, and fecal coliform bacteria and *E. coli* are measured from the same culture.

Table 4.2 shows the specific nutrients, metals, and hydrocarbons analyzed at independent state or federally certified laboratories. Due to the costs of analyzing water quality samples for metals and petroleum hydrocarbons, these parameters are only measured quarterly at two of the water quality monitoring sites (one freshwater site downstream from a petroleum oil refinery and one marine water site within a recreational boat marina). Similarly, due to cost considerations, nutrients are measured quarterly at only five of the surface water quality monitoring sites. Depending on the specific intent of the sampling effort, nutrients analyzed range from ammonia, nitrite+nitrate-N, and total phosphorus for "first flush" sample runs during the onset of the rainy season, to the same three parameters plus 5-day biochemical oxygen demand (BOD), Total Kjeldahl Nitrogen (TKN), orthophosphate, total organic carbon, total suspended solids, total volatile suspended solids, total alkalinity, pH+temperature, sulfate, sulfide, chlorophyll *a*, iron, silicon, and pheophytin. Metals analyzed include mercury, zinc, copper, and arsenic at Site SW001 and chromium, copper, lead, and zinc at Site SW014. The Site SW001 location is near the Sandy Point Marina and the Site SW014 location is along the stream that drains from the Phillips66 (previously ConocoPhillips) petroleum oil refinery located along the western extent of the northern Reservation boundary. At both of these sites, petroleum hydrocarbons, pH+temperature, and total hardness are also measured. During the 2012 sampling season, nutrients, metals and hydrocarbon samples were collected for all four quarters where sample sites had flowing water. Several sites were dry or not flowing during the third quarter and one site was not flowing during the third or fourth quarter so water quality data were not collected at those sites.

Starting in January 2010 continuous water temperature dataloggers were deployed at 10 surface water quality sites throughout the Reservation. Water temperature is measured continuously and the measured temperature averaged and recorded at 30 minute increments at each site. The water temperature data are downloaded on a monthly basis. The collected data are used to calculate the 7-day average of the daily maximum temperature for freshwater sites and the 1-day maximum temperature for marine water sites, which allows for a direct comparison with the applicable water quality standards. Due to lost equipment, seven sites have a complete dataset, two sites have 8-8.75 months of data, and one site does not have any data for 2012.

A major change in data collection occurred during 2011 with the addition of a custom electronic interface, which allows for real-time data entry from the field. The user's interface functions with an iPad platform, connecting to the surface and ground water database through remote network access and 3G connection. Data are field entered as they are collected, providing timely entry of data into the database and greatly improving data management. Before the user's interface was developed all data were collected on field sheets and transcribed into the database from the office. This improvement in efficiency has resulted in a significant time savings for the Program.

The quality assurance protocols identified in the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010) were followed for the sample collection in 2012. A quality assurance review strategy was developed and implemented in October 2014 to validate, assign quality ratings, and finalize data collected as part of the ambient water quality monitoring program. All Program data were validated between October 2014 and January 2015 and uploaded to WQX for inclusion in the STORET database. The data collected during 2012 are provided in Appendix A and were exported to WQX on February 1, 2013.

Table 4.1 Surface Water Quality Monitoring Sites

Run Name	Sample Sites Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
Floodplain East (FPE)	15, 16, 17, 51, 52, 55, 56, 59, 72, 118	Air temperature, salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly	Site 118 along the Nooksack River is measured in all surface water sample runs, providing information on a known pollutant source to Portage Bay. Site 51 is measured in both the FPE and FPW runs.
Floodplain West (FPW)	3, 8, 9, 10, 11, 12, 13, 14, 51, 53, 58, 118	Air temperature, salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, DO, pH, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly	Site 118 along the Nooksack River is measured in all surface water sample runs, providing information on a known pollutant source to Portage Bay. Site 51 is measured in both the FPE and FPW runs.
Lummi Shore Road (LSR)	7, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 118	Air temperature, salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, DO, pH, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly in coordination with the DOH sampling of Portage Bay Sites along Lummi Shore sampled from north to south or from south to north	Occasionally Site 118 is sampled at beginning and end of run if Portage Bay sampling occurs late in the morning or afternoon.
Marine Boat-Accessible (Marine)	1, 2, 6, 19, 22, 23, 24, 25, 26, 27, 28	Salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, Secchi depth, water/level depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	Monthly, as needed	Measure flow at the Portage Island sites (sites numbered 24 through 28) when channel and flow conditions are appropriate.

Table 4.1 Surface Water Quality Monitoring Sites

Run Name	Sample Sites Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
Lummi Bay DOH Support	DOH 285, DOH 286, DOH 287, DOH 288, DOH 38, DOH 39, DOH 40, DOH 41, DOH 42, DOH 43, DOH 44, DOH 45	Salinity-based stratification, water temp., salinity, specific conductivity, current/flow direction, DO, pH, Secchi depth, water level/depth, turbidity, and general observations	Fecal coliforms	Six times annually	Washington Department of Health (DOH) provides sample bottles and bacteria enumeration. Logistical difficulties prevent DOH staff from sampling Lummi Bay: tidal window for access to marine sample sites in Portage and Lummi bays is narrow, particularly in the summer (+8.5ft MLLW tide minimum is required). LNR staff collects bacteria samples and measures other water quality for comparison with water quality standards.
Lummi Bay Watershed First Flush	11, 10, 12, 13, 9, 58, 8, 3, 53, 51, 118 Time permitting: 14, 59, 15, 16, and 17	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water level/depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	As needed based upon predicted and observed runoff during the onset of the rainy season	Site 118 along the Nooksack River is measured in all surface water sample runs, providing information on a known pollutant source to Portage Bay. Site 51 is measured in both the FPE and FPW runs.
Bellingham Bay Watershed First Flush	7, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 118	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water level/depth, turbidity, and general observations	Fecal coliforms, *E. coli*, and enterococcus	The day following the Lummi Bay First Flush sample run	Sites along Lummi Shore Road sampled from north to south or from south to north. Site 29 samples a relatively undeveloped Lummi Peninsula upland watershed and is used as a control site representing a watershed that is minimally affected by development.

Table 4.2 Parameters Measured Quarterly at Selected Sites

Sample Site Number(s)	Group Name	Parameters	Frequency of Collection	Notes
1	Hydrocarbons	Diesel and Lube Oil range hydrocarbons	Quarterly (depending on the year)	Sample collected in 1-L glass amber bottle. (Monday and Tuesday. Wednesday with prior lab approval)
	Metals	Arsenic, Copper, Mercury, Tin, Zinc, Hardness, and pH with the temperature of the water sample at the time of measurement	Quarterly (depending on the year)	Sample collected in 1-L plastic bottle. (Monday and Tuesday. Wednesday with prior lab approval)
2, 3, 6, 9, 15	Nutrients	Alkalinity, Ammonia, Biochemical Oxygen Demand, Nitrate-N, Nitrite-N, Total Kjeldahl Nitrogen, Ortho Phosphate, Total Phosphorus, pH [with temperature at time of measurement], Total Organic Carbon, Total Suspended Solids, Total Volatile Suspended Solids, Iron, Sulfate, Chlorophyll a, Sulfide, Silicon, Pheophytin and Chemical Oxygen Demand	Quarterly (depending on the year)	Samples collected in 4 1-L plastic bottles and 2 40-mL vials with a preservative. Nitrite and Nitrate are normally combined. (Monday and Tuesday. Wednesday with prior lab approval)
14	Hydrocarbons	Diesel and Lube Oil range hydrocarbons	Quarterly and First Flush (depending on the year)	Sample collected in 1-L glass amber bottle. (Monday and Tuesday. Wednesday with prior lab approval)
	Metals	Chromium, Copper, Lead, Zinc, Hardness and pH with the temperature of the water sample at the time of measurement	Quarterly and First Flush (depending on the year)	Sample collected in 1-L plastic bottle. (Monday and Tuesday. Wednesday with prior lab approval)

4.3.Groundwater Field Data Collection

Twenty-seven (27) groundwater sample sites (Figure 4.2) were selected for regular monitoring to characterize the two major potable aquifer systems on the Reservation. Table 4.3 lists the well sampling groups, wells in each group, well number, parameters measured, and measurement frequency. The number of wells sampled has increased over the years but the parameters measured have not changed, other than the addition of pH and salinity measurement. Wells were added to the Program as they were drilled or when access was granted to obtain better spatial resolution of aquifer conditions. Water level, pumping status, temperature, specific conductivity, pH, salinity, and chloride concentration are measured monthly or more frequently at each site. Well production is recorded from existing meters at the Lummi Water District water supply wells.

Sample sites were selected to represent aquifer-wide conditions as practicable, but the spatial representativeness of these sampling points is limited by the lack of existing groundwater wells in some parts of the Reservation, particularly along the interior of the Lummi Peninsula and the eastern part of the northwestern upland.

The primary sources of variability are seasonal changes (i.e., wet season and dry season) and pumping regimes (which are typically related to season). This variability is addressed through frequent sampling (sub-monthly to monthly), performing multiple well water level measurements during sampling at each well, and recording the pumping rate, totalizer values (if metered), and pump status of the well at the time of measurement. Water quality is generally stable in the wells.

The chloride concentration, pumping rate and amounts, and water levels of the water supply wells provide critical information about aquifer condition, pumping regimes, and the need for protective measures as these data indicate whether saltwater intrusion is occurring or if the likelihood of saltwater intrusion has increased. For wells that are not used for water supply purposes (e.g., inactive wells), water level provides information about aquifer conditions.

Figure 4.2 Groundwater Quality Monitoring Sample Sites

Table 4.3 Groundwater Quality Monitoring Wells

Well Group	Wells	Well Number	Parameters Measured At Each Sample Site	Measurement Frequency
Domestic Wells	R. Jefferson	112	Water level	Monthly
	K. Charles	74	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	Berg	143	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	Bewley	164	Water level	Monthly
	M. Egawa	189	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	J. Finkbonner	109	Chloride, temperature, specific conductivity, pH, salinity, water level infrequently	Monthly
	T. Teeter	413	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
	Skolrood	101	Water level, chloride, temperature, specific conductivity, pH, salinity	Monthly
Potable Public Water Supply Wells	Balch	115	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Horizon	58	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Kinley Way (Kinley 1)	59	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Kinley 2	409	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Kinley 3	421	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Mackenzie 2	129	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Northwest Well 2 (NW2)	418	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	West Shore	146	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Gooseberry Point 4	419	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed
	Gooseberry Point 5	420	Water level, water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed

Table 4.3 Groundwater Quality Monitoring Wells

Well Group	Wells	Well Number	Parameters Measured At Each Sample Site	Measurement Frequency
Monitoring Wells	Hopkins	111	Water level, datalogger upload	Monthly
	Cultee	56	Water level, datalogger upload	Monthly
	Revey	127	Water level, datalogger upload	Monthly
	Mackenzie 3	405	Water level, datalogger upload	Monthly
	Mackenzie 4	422	Water level	Monthly
	Pierre	66	Water level, datalogger upload	Monthly
	Northwest Well 1 (NW1)	417	Water level, datalogger upload	Monthly
Other Wells	Johnson	145	Water level, datalogger upload, water use, chloride, temperature, specific conductivity, pH, salinity, tank level, and discharge from manifold in tank Flow rate and totalizer at all meters except M. Finkbonner (Nau) and Greg Finkbonner meters every visit to Johnson well. The latter two meters are measured monthly	Weekly or more frequently for water quality, water level, and water use
	Northwest Well 3 (NW3)	441	Water use, chloride, temperature, specific conductivity, pH, salinity	Monthly, or more as needed

5. LUMMI NATION SURFACE WATER QUALITY STANDARDS

The purpose of this section of the report is to summarize the Lummi Nation Surface Water Quality Standards (LWRD 2008a). The Water Quality Standards (WQS) for Surface Waters of the Lummi Indian Reservation were adopted by the Lummi Nation in August 2007 and approved by the EPA on September 30, 2008. The standards are summarized in Table 5.1. Figure 5.1 shows the surface waters of the Lummi Nation, water body classifications for the surface waters, and the current sampling locations.

Because of the Reservation location in the Nooksack River and Lummi River estuaries, many Reservation water bodies are seasonally brackish. This temporal and spatial variability creates uncertainty regarding whether or not marine or fresh water standards apply. To remove this uncertainty, the approach taken in developing the water quality standards for the surface waters of the Reservation was to identify specific geographic locations as the demarcation between fresh and marine waters. These locations are depicted in Figure 5.1. A line between Fish Point and Treaty Rock separates freshwater and marine water in the Nooksack River Delta. The location where the water body flows under Hillaire Road separates the freshwater and marine water in the Lummi River Delta, which corresponds with sample site SW008 shown on Figure 5.1.

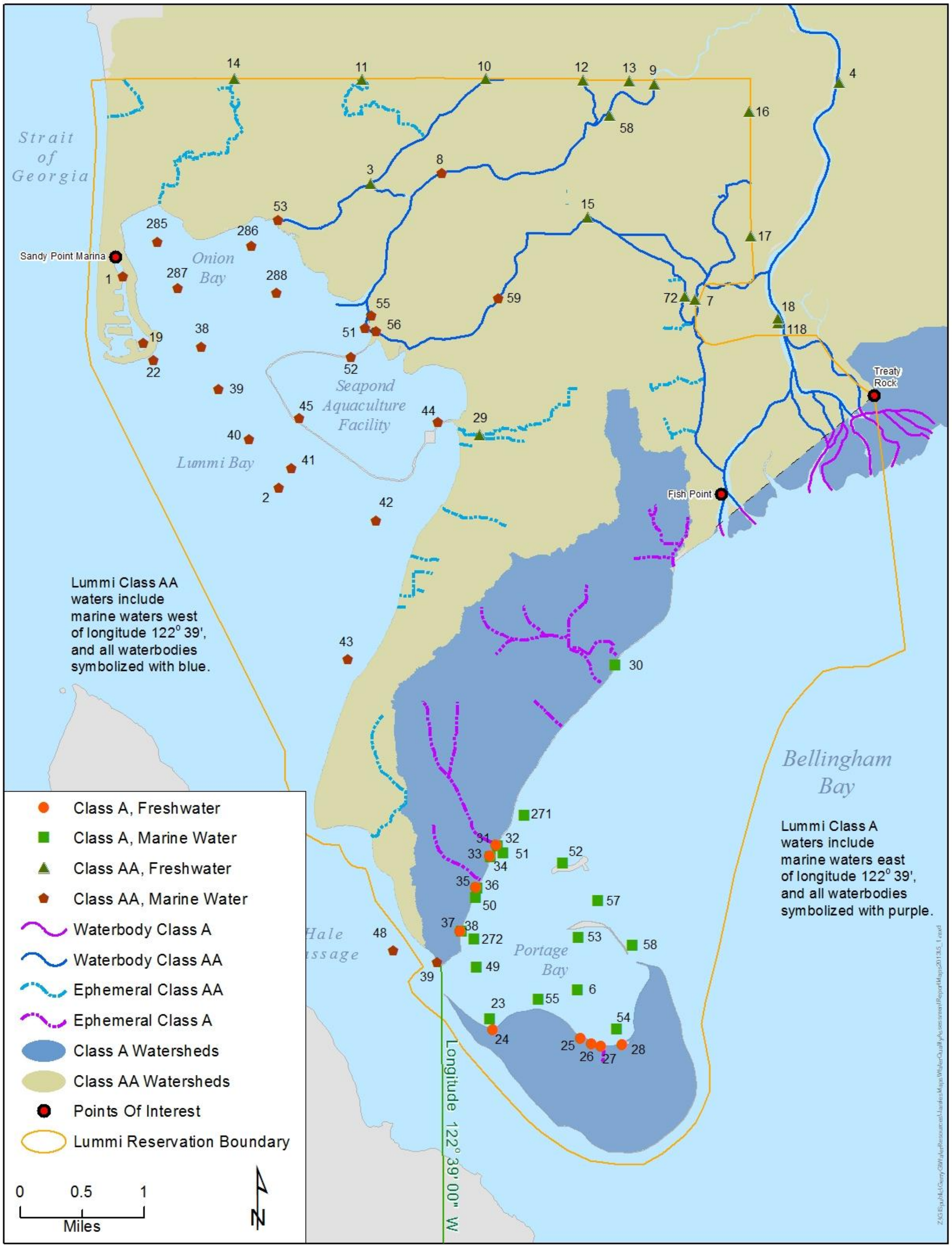

Figure 5.1 Classification of Lummi Nation Waters and Current Sampling Locations

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
General Characteristics	Uniformly exceeds the requirements for all or substantially all uses	Meets or exceeds the requirements for all or substantially all uses	Meets or exceeds the requirements for most uses	Meets or exceeds the requirements for all or substantially all uses

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
Characteristic Uses	**(A)** Water supply (domestic, commercial, municipal, industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam, oyster, and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, geoduck, etc.) rearing, spawning, and harvesting. **(D)** Wildlife habitat. **(E)** Recreation (extraordinary primary contact, primary contact, sport fishing, boating, canoeing, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural	**(A)** Water supply (domestic, commercial, municipal, industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam, oyster, and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, geoduck, etc.) rearing, spawning, and harvesting. **(D)** Wildlife habitat. **(E)** Recreation (primary contact, sport fishing, boating, canoeing, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural	**(A)** Water supply (industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam, oyster, and mussel rearing and spawning. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, geoduck, etc.) rearing and spawning. **(D)** Wildlife habitat. **(E)** Recreation (secondary contact, sport fishing, boating, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural	**(A)** Water supply (domestic, commercial, municipal, industrial, agricultural). **(B)** Stock watering. **(C)** Fish and shellfish: Salmonid migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Other fish migration, juvenile rearing, spawning, egg incubation, fry emergence, and harvesting. Clam and mussel rearing and spawning. Crayfish rearing and spawning. **(D)** Wildlife habitat. **(E)** Recreation (extraordinary primary contact, primary contact, sport fishing, boating, canoeing, and aesthetic enjoyment). **(F)** Commerce and navigation. **(G)** Tribal Cultural

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
Freshwater Fecal Coliform Bacteria Geometric Mean Density	Shall both not exceed 50 colonies/100 ml AND not exceed 100 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 100 colonies/100 ml AND not exceed 200 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 200 colonies/100 ml AND not exceed 400 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 50 colonies/100 ml AND not exceed 100 colonies/100 ml in more than 10% of the samples obtained for calculation purposes
Marine Water Fecal Coliform Bacteria Geometric Mean Density	Shall both not exceed 14 colonies/100 ml AND not exceed 43 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 14 colonies/100 ml AND not exceed 43 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	Shall both not exceed 100 colonies/100 ml AND not exceed 200 colonies/100 ml in more than 10% of the samples obtained for calculation purposes	N/A
Freshwater Enterococci	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 61 colonies/100 ml	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 61 colonies/100 ml	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 78 colonies/100 ml	Shall both not exceed a geometric mean density of 33 colonies/100 ml AND not exceed a single sample maximum allowable density of 61 colonies/100 ml
Marine Water Enterococci	Shall both not exceed a geometric mean density of 35 colonies/100 ml AND not exceed a single sample maximum allowable density of 104 colonies/100 ml	Shall both not exceed a geometric mean density of 35 colonies/100 ml AND not exceed a single sample maximum allowable density of 104 colonies/100 ml	Shall both not exceed a geometric mean density of 35 colonies/100 ml AND not exceed a single sample maximum allowable density of 158 colonies/100 ml	N/A

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	Class A Excellent	Class B Good	Lake Class
Freshwater Dissolved Oxygen Concentration	The seven-day mean minimum shall both not be less than 11.0 mg/l AND not have a spatial median intergravel dissolved oxygen concentration below 8.0 mg/l. If minimum spatial median intergravel dissolved, oxygen is 8.0 mg/l or greater, the minimum dissolved oxygen criterion is 9.0 mg/l. Where barometric pressure and temperature preclude attainment of criteria, dissolved oxygen must not be less than 95% of saturation.	Shall not be less than 8.0 mg/l. Where barometric pressure and temperature preclude attainment of criteria, dissolved oxygen must not be less than 90% of saturation.	Shall not be less than 6.5 mg/l.	No measurable decrease from natural conditions
Marine Water Dissolved Oxygen Concentration	Shall exceed a 1-day minimum daily concentration of 7.0 mg/l	Shall exceed a 1-day minimum daily concentration of 6.0 mg/l	Shall exceed a 1-day minimum daily concentration of 5.0 mg/l	N/A
Freshwater Temperature	Shall not exceed a 7-day average of the daily maximum value (7DADM) temperature of 16.0°C. For summertime spawning, temperature shall not exceed a 7DADM temperature of 13.0°C.	Shall not exceed a 7DADM temperature of 17.5°C.	Shall not exceed a 7DADM temperature of 17.5°C.	No measurable increase from natural conditions
Marine Water Temperature	Shall not exceed a 1-day maximum temperature of 13.0°C	Shall not exceed a 1-day maximum temperature of 16.0°C	Shall not exceed a 1-day maximum temperature of 19.0°C	N/A

Table 5.1 Summary of Water Quality Criteria and Uses of the Various Classes of Lummi Indian Reservation Surface Waters

Parameter	Surface Water Classes of the Lummi Indian Reservation			
	Class AA Extraordinary	**Class A Excellent**	**Class B Good**	**Lake Class**
Freshwater pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	No measurable change from natural conditions
Marine Water pH	7.0 – 8.5	7.0 – 8.5	7.0 – 8.5	N/A
Turbidity	Shall not exceed 5 NTU over background turbidity when background turbidity is less than or equal to 50 NTU OR not increase by more than 10% when the background turbidity is greater than 50 NTU	Shall not exceed 5 NTU over background turbidity when background turbidity is less than or equal to 50 NTU OR not increase by more than 10% when the background turbidity is greater than 50 NTU	Shall not exceed 5 NTU over background turbidity when background turbidity is less than or equal to 50 NTU OR not increase by more than 20% when the background turbidity is greater than 50 NTU	Shall not exceed 5 NTU over background turbidity
Toxic, Radioactive, Or Deleterious Material Concentrations	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.	Shall be less than concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chromic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health as determined by the Director.
Aesthetic Values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste or taint the flesh of edible species

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6. SURFACE WATER QUALITY SAMPLE RESULTS AND REGULATORY COMPLIANCE

Water quality sample results for 2012 and for the period of record through 2011 were compared with the applicable water quality standards associated with each sample site. Maximum and minimum or as appropriate the geometric mean and 90th percentile water quality sample results are depicted as vertical bars in the graphs presented in this section of the report. Water quality standard values are presented as horizontal lines on the graphs where standard values apply for a particular parameter. Sample site identification codes, corresponding to the sample site locations shown in Figure 4.1 and Figure 4.2 and listed in Table 4.1 and Table 4.3, are presented along the X-axis. The number of observations/sample results is shown just above the X-axis next to the respective bar. Turbidity results are depicted differently because turbidity water quality standards are expressed as relative to the background turbidity level, which is dependent on a number of factors including flow, time of year, and sediment load. The turbidity sample results are averaged to characterize the relative turbidity levels at each sample site. Although there are currently no applicable water quality standards, the sample results for total suspended solids (a measure of turbidity), phosphorus, and total nitrogen are also summarized.

The water quality sample results for 2012 were then used to generate water quality maps for select parameters to illustrate how frequently a sample site achieved the associated water quality standard. In the case of bacteria, the water quality maps indicate how frequently and whether the standard was fully or partially achieved during 2012.

6.1.Water Quality Results

The use of bar graphs to present the sample program results allows:

- The various sites within a specific water body classification to be compared to each other;
- The sample results to be compared with the applicable water quality standards;
- The sample results from 2012 to be compared with the sample results over the period of record through 2011.

However, the bar graphs do not allow for a presentation of seasonal variations or trends as the data are for the entire reporting period for the site rather than over time. In addition, because the bar graphs for water temperature, dissolved oxygen, and pH show the maximum and minimum of the measured values, a single measurement above or below a water quality criteria/threshold suggests that the standards are not achieved at the site even though a single sample result may be an anomaly.

To address these limitations, the bar graphs for the various parameters are supplemented with graphs and box-and-whisker plots from a representative sample site from the same water body classification to depict seasonal variations and trends over the period of record. Also, the continuous water temperature data from nine sites were used to calculate the 7-day average of the daily maximum for freshwater sample sites and the 1-day maximum temperature for marine water sample sites, which allows for a direct comparison with the applicable water quality standards and was used to depict the seasonal change in water temperature during 2012.

The selected representative freshwater sample sites are along the Lummi River and the Nooksack River. The continuous water temperature sites are along the Lummi River, Jordan Creek, Smuggler's Slough, and Schell Creek. The Lummi River and Nooksack River are the two largest freshwater bodies that discharge to marine waters on the Reservation. All of the water bodies originate off-Reservation except Smuggler's Slough and are classified as Class AA waters. Because all of the Class A freshwater bodies are ephemeral streams that are seasonally dry, have low discharges when they have flow during the rainy season, and have been shown to have minimal or no measurable impact on the water quality of the receiving marine waters (LWRD 1999, LWRD 2006a, LWRD 2006b), a Class A freshwater body was not selected as a representative site or continuous water temperature monitoring site. As a result, the representative freshwater site associated with the Class A marine water site is a Class AA site located along the Nooksack River (Site SW018/SW118). The representative sample sites used to depict seasonal variations and trends are the following:

- Class AA Freshwater: Site SW009 (Lummi River at Slater Road)
- Class AA Marine Water: Site SW002 (Lummi Bay)
- Class AA Freshwater: Site SW118 (Nooksack River below Marine Drive – formerly Site SW018[1]).
- Class A Marine water: Site SW030 (Bellingham Bay between the Nooksack River Delta and Portage Bay)

6.2.Water Quality Maps

Water quality maps were generated from the 2012 water quality data for water temperature, dissolved oxygen, and pH to illustrate whether a sample site achieved the associated water quality standard 100% of the time sampled, greater than or equal to 75% of the time sampled, or less than 75% of the time sampled. In the case of fecal coliform bacteria and enterococcus bacteria the water quality maps indicate whether the associated water quality standard was fully or partially achieved 100% of the time sampled, fully or partially achieved greater than or equal to 75% of the time sampled or fully or partially achieved less than 75% of the time sampled during 2012.

6.3. Fecal Coliform Bacteria Results

Bacteria sampling is routinely conducted at each of the surface water quality sampling locations. Pursuant to the *Lummi Nation Water Quality Monitoring Program Quality Assurance/Quality Control Plan – Version 4.0* (LWRD 2010), the collected samples are transported on ice to a contracted analytical laboratory the day of collection and tested for

[1]Sample Site SW018 was moved approximately 200 feet downstream along the west bank of the Nooksack River during 2008 to ensure safe access to the sampling location. The new sample site location was assigned the identifier Site SW118 but the samples at this site are from essentially the same water that was sampled at the discontinued Site SW018.

fecal coliform bacteria, *E. coli,* and enterococcus. Water from one sample bottle is used for each of the tests, and fecal coliform bacteria and *E. coli* are enumerated from the same growth plates.

To allow comparison to the applicable water quality standards, the bar graphs for the bacteria types depict the geometric mean and 90th percentile for fecal coliform bacteria and *E. coli* and the geometric mean and maximum value for enterococcus bacteria for each site. As summarized in Table 5.1, the water quality standards for enterococcus bacteria set maximum bacteria counts. If sample results show a higher count than the applicable water quality standard, the water quality standard is not met and the characteristic uses of the water body are not supported.

6.3.1. Class AA Waters

The Class AA freshwater standards for fecal coliform bacteria are a geometric mean not to exceed 50 colony forming units (cfu) per 100 milliliters (ml) <u>and</u> a 90th percentile standard of 100 cfu/100 ml (from the values used to calculate the geometric mean). As shown in Figure 6.1, 3 of 15 Class AA freshwater sites sampled during 2012 achieved both the geometric mean and 90th percentile standard. As shown in Figure 6.3, 9 of the 12 Class AA freshwater sample sites that did not achieve both the geometric mean and 90th percentile standard achieved at least part of the water quality standard during 2012. However, as only part of the standard was met the water quality standard for fecal coliform bacteria was not achieved at those sites. As shown in Figure 6.2, the geometric mean was below the standard at 10 of the 17 sites over the period of record. However, because the 90th percentile criterion was exceeded at all of the sites, the water quality standard for fecal coliform bacteria was not achieved at any of the Class AA freshwater sites for the period of record. As shown in Figure 6.1, the highest geometric mean detected during 2012 was at Site SW004 (on the Nooksack River at the Slater Road bridge); however, this data reflects the laboratory findings from a single sample. The site with the second highest geometric mean and the highest 90th percentile during 2012 was Site SW011 along Jordan Creek at Slater Road (the northern Reservation boundary). Sample sites along the northern Reservation boundary (i.e., SW009, SW010, SW011, SW012, SW013, and SW014) have some of the highest fecal coliform bacteria geometric means and 90th percentiles over the period of record. Sample Site SW029, which drains a forested area west of Chief Martin Road, and Sites SW003 (northern Lummi River distributary channel) and SW072 (Smuggler Slough), also experienced periodic high fecal coliform bacteria counts. All of these water bodies discharge to Lummi Bay where important shellfish beds are located.

Site SW118 is located along the Nooksack River where it flows onto the Reservation. High bacteria densities at this site represent a threat to the shellfish beds within and adjacent to Portage Bay and to the people who consume shellfish from these areas. The geometric mean for SW118, based on the most recent 30 sampling events during 2012, was 41 cfu/100 ml. This geometric mean is lower than the Lummi Nation fecal coliform bacteria geometric mean standard of 50 cfu/100 ml, but above the Total Maximum Daily Load (TMDL) target of 39 cfu/100 ml established for the lower Nooksack River (Ecology 2000, 2002). The TMDL was established by the Washington Department of Ecology (Ecology) to be protective of the shellfish beds within and adjacent to Portage Bay and to protect the health of people who consume shellfish from these waters. The 90^{th} percentile value at SW118, based on the most recent 30 samples collected at this site during 2012, was 272 cfu/100 ml, which is nearly triple the 90^{th} percentile standard of 100 cfu/100 ml for a Class AA freshwater stream. Unlike in 2010 and 2011, the fecal coliform water quality standard at Site SW118 was not achieved during 2012 and therefore the designated uses are not being supported.

The Class AA marine water quality standards for fecal coliform bacteria are more stringent than for Class AA freshwater and include a geometric mean not to exceed 14 cfu/100 ml and a 90^{th} percentile (from the values used to calculate the geometric mean) standard of 43 cfu/100 ml. As shown in Figure 6.4, 17 of the 24 sample sites met these criteria during 2012. As shown in Figure 6.3, of the 7 sites that did not achieve both the geometric mean and 90^{th} percentile standard, 1 of those sites partially achieved the water quality standard during 2012. However, as discussed previously as only part of the standard was met the water quality standard for fecal coliform bacteria was not achieved at those sites. As shown in Figure 6.5, all 17 of the sites that met the criteria in 2012 also met the criteria for the period of record through 2011.

As shown in Figure 6.6, the fecal coliform bacteria sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009 on the Lummi River along the northern Reservation boundary) have been consistently above the geometric mean and the 90^{th} percentile criteria over the period of record. In contrast, as shown in Figure 6.7, the fecal coliform bacteria sample results for the representative Class AA marine water site (SW002 in Lummi Bay) have been consistently below the geometric mean and 90^{th} percentile criteria over the period of record.

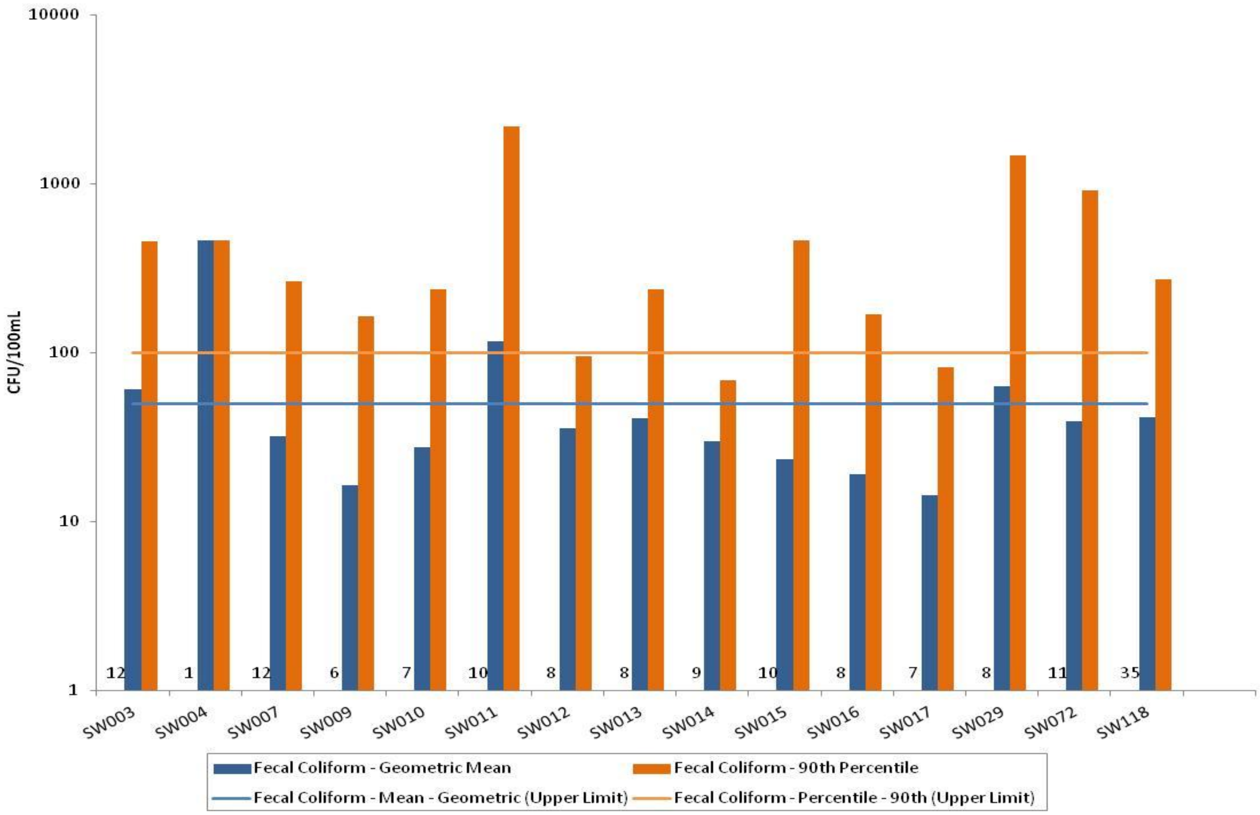

Figure 6.1 Class AA Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2012

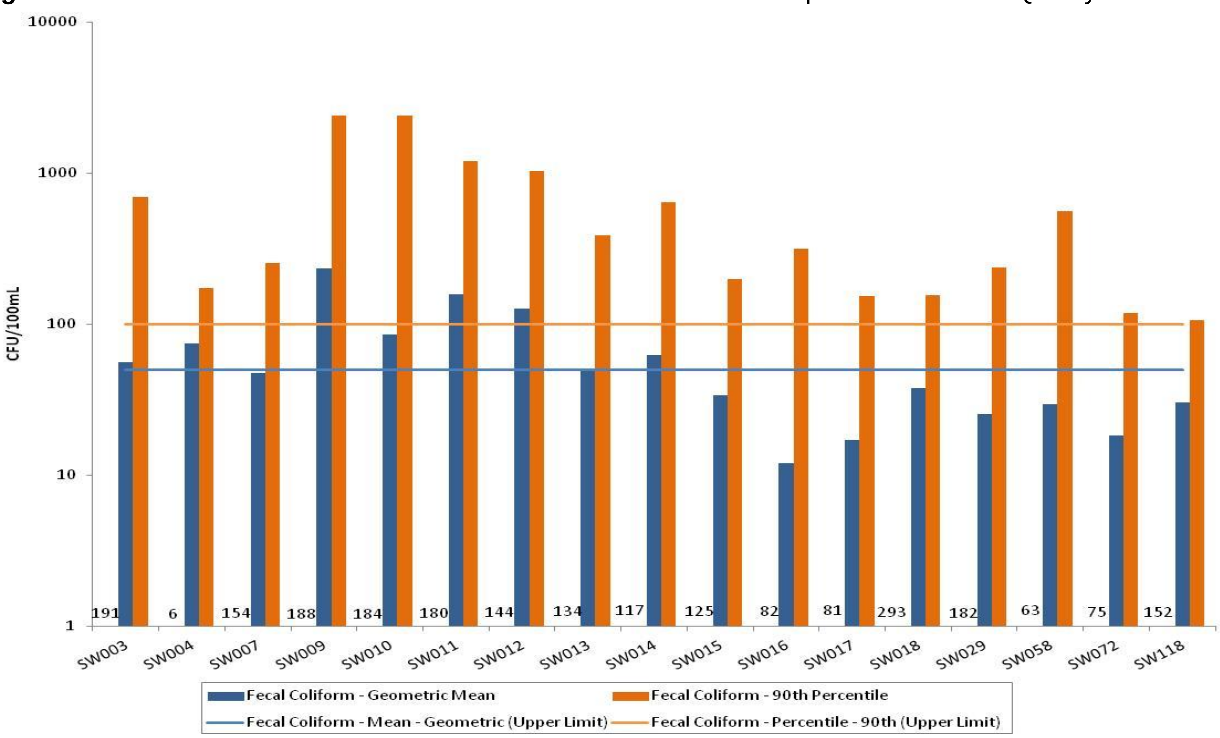

Figure 6.2 Class AA Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

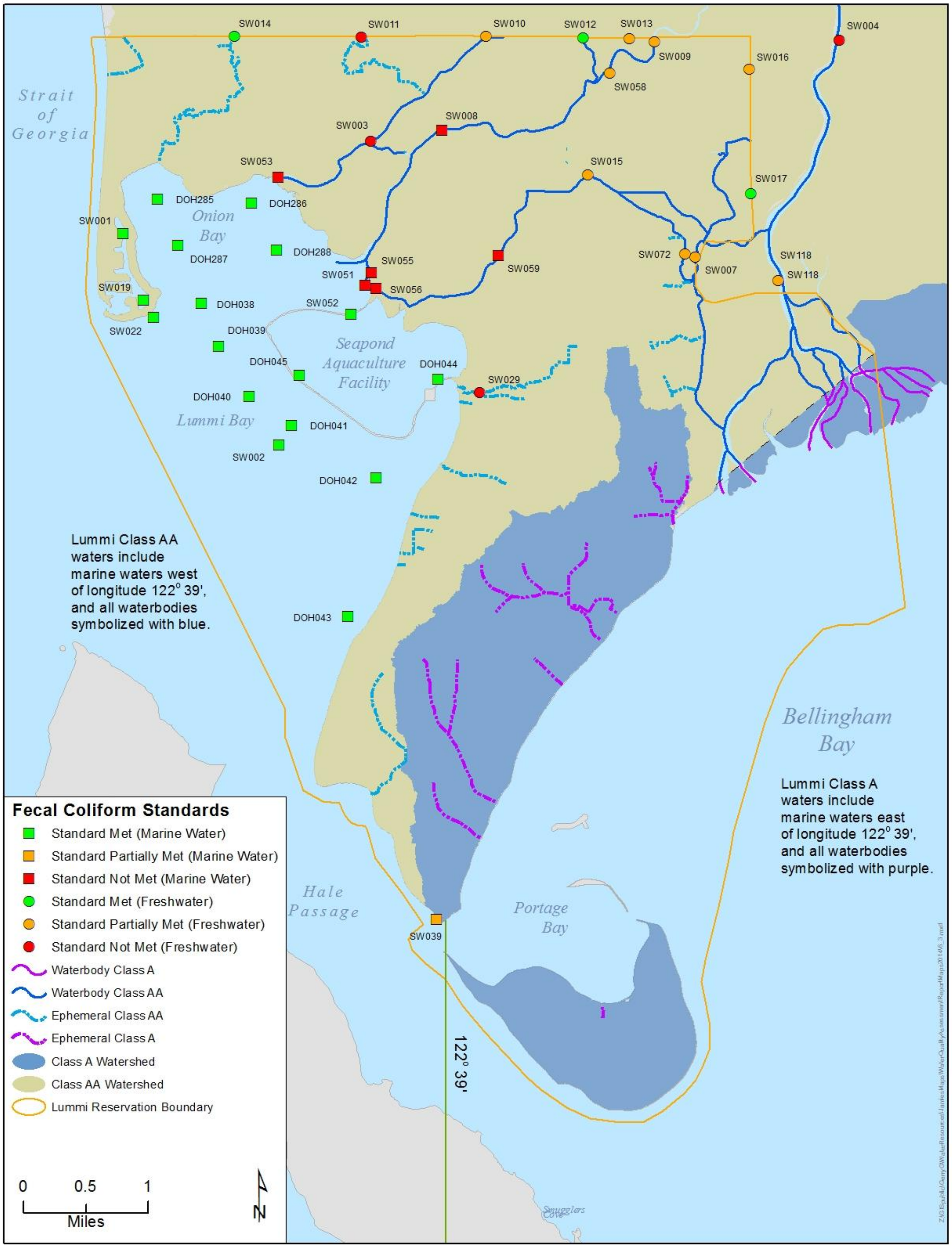

Figure 6.3 Class AA Freshwater and Marine Water Fecal Coliform Compliance with Water Quality Standards: 2012

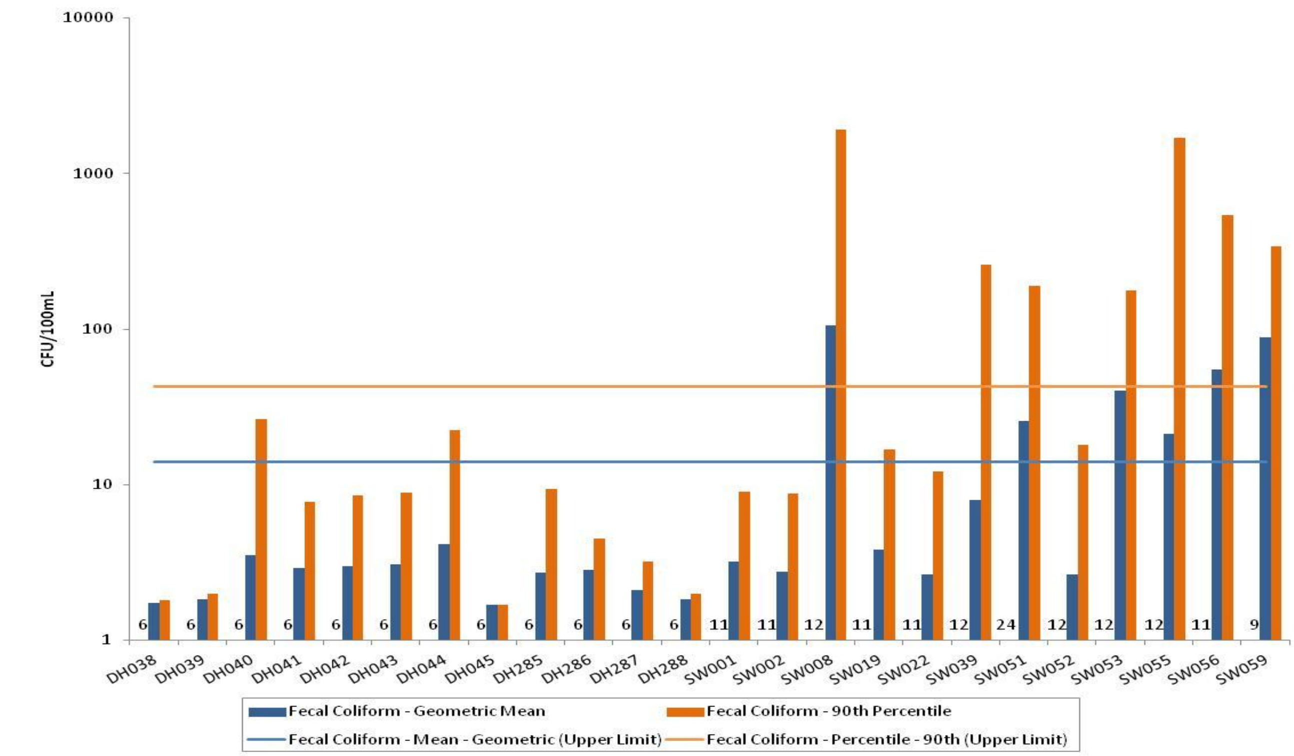

Figure 6.4 Class AA Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2012

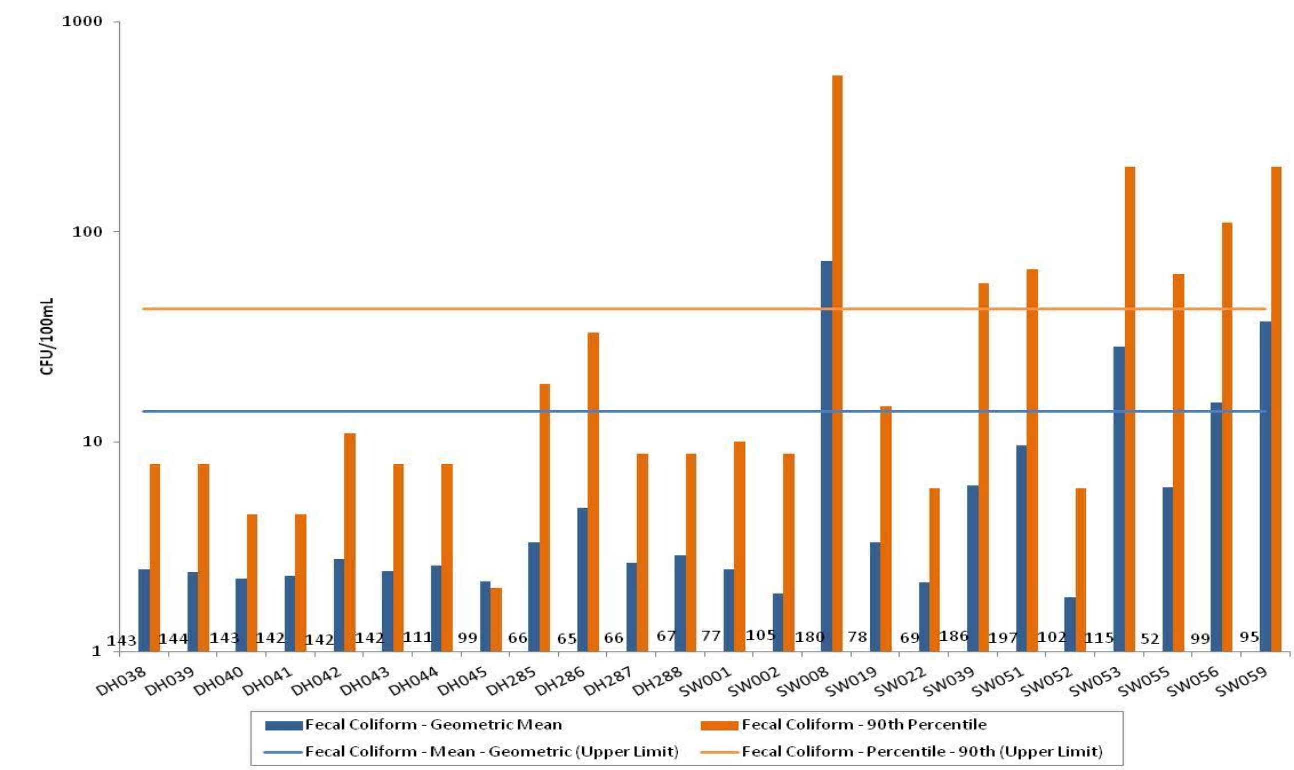

Figure 6.5 Class AA Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

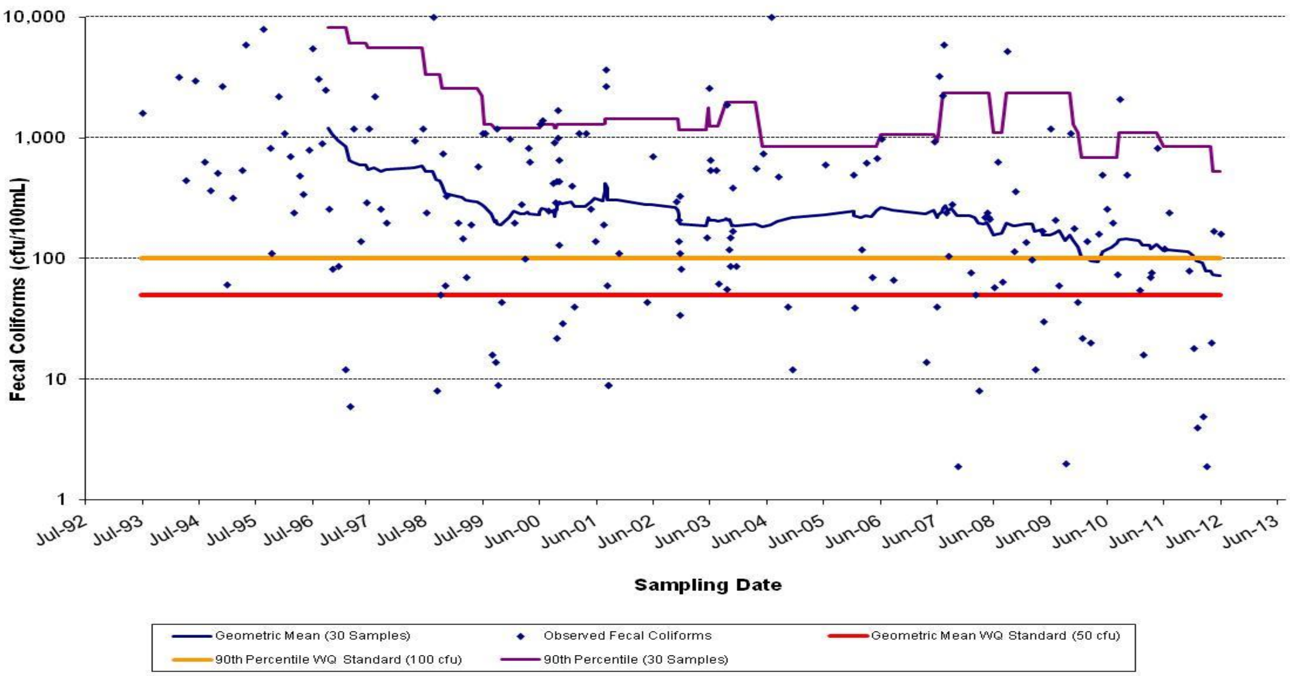

Figure 6.6 Class AA Freshwater Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW009

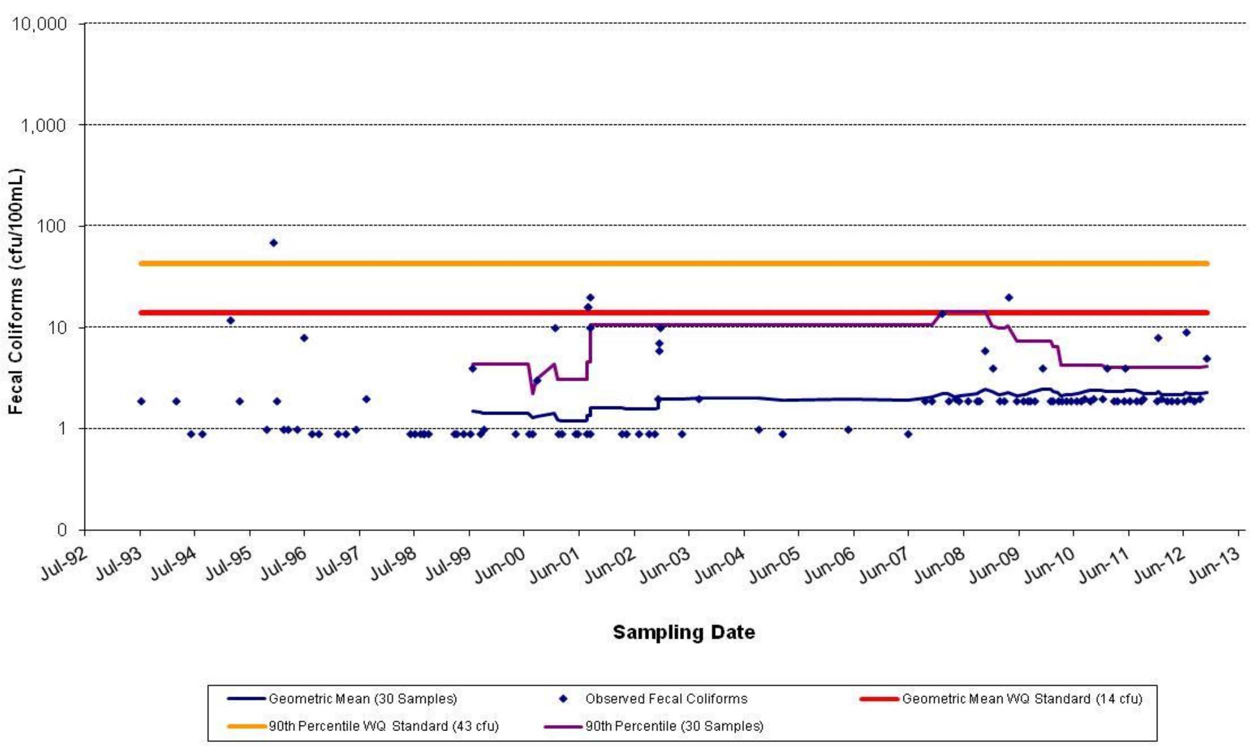

Figure 6.7 Class AA Marine Water Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW002

6.3.2. Class A Waters

The Class A freshwater standard for fecal coliform bacteria are a geometric mean not to exceed 100 cfu/100 ml and a 90th percentile (from the values used to calculate the geometric mean) not to exceed 200 cfu/100 ml. As shown in Figure 6.8 all of the Class A freshwater sites sampled in 2012 met the standard for geometric mean, however Site SW027 did not achieve the 90th percentile standard during 2012 and therefore designated uses are not being supported. As shown in Figure 6.10 only one of the Class A freshwater sites, Site SW027, did not achieve both the geometric mean and the 90th percentile standard, but partially achieved the standard in 2012. As shown in Figure 6.9, the geometric mean was below the standard at all 9 Class A freshwater sample sites for the period of record through 2011, but the 90th percentile values were above the standard at all the sites, except Site SW031, which drains a forested wetland along Lummi Shore Road. The sites with the highest geometric mean and 90th percentile are located on Portage Island (SW024, SW025, SW026, SW027, and SW028) with an additional site on the south end of Lummi Shore Road (SW037). Although elevated fecal coliform bacteria levels have been sampled at the Class A freshwater sites, as noted above, the water bodies are seasonally dry and have low discharges during the rainy season. The results from an intensive sampling effort in the adjacent area along the Lummi Peninsula suggest that discharge from these sites have minimal or no measurable impact on the water quality of the receiving marine waters (LWRD 1999, LWRD 2006a, LWRD 2006b).

The Class A marine water quality standards for fecal coliform bacteria are more stringent than for Class A freshwater quality standards and include a geometric mean not to exceed 14 cfu/100 ml and a 90th percentile (from the values used to calculate the geometric mean) not to exceed 43 cfu/100 ml. As shown in Figure 6.11, the standards were met at 9 of the 18 sample sites during 2012. As shown in Figure 6.10, of the 9 sample sites that did not achieve the water quality standard, 5 sites achieved a portion of the standard during 2012. However, because both the geometric mean and 90th percentile criterion were exceeded, the water quality standard for fecal coliform bacteria was not achieved at those sites. As shown in Figure 6.12, 9 of the 18 sites met the criteria for the period of record and all 18 sites had geometric means below the standard for the period of record.

Figure 6.13 depicts the 30 sample running geometric mean and 90th percentile of fecal coliform bacteria at the mainstem of the Nooksack River just below the Marine Drive Bridge (SW018/SW118). Site SW018/SW118 is the representative Class AA freshwater site that contributes to a Class A marine water site. As shown in Figure 6.13, from 1998 through 2003 there is a general trend of decreasing fecal coliform bacteria densities. During late 2003 through 2004, fecal coliform bacteria densities increased and exceeded both the Lummi Nation Water Quality Standards (WQS) for Class AA freshwater and the TMDL target (Ecology 2000, 2002). Fecal coliform bacteria levels dropped below the Lummi Nation WQS and the TMDL target during late 2005 through early 2007. During this period, there also was reduced sampling due to staff changes. The fecal coliform bacteria geometric mean decreased to below the TMDL Target in 2008 and 2009 however there continued to be periodic samples with high fecal coliform bacteria levels in the Nooksack River. Consequently, the fecal coliform bacteria levels were not meeting the 90th percentile standard in 2008 or 2009. During 2010 and 2011 water quality improved and Site SW018/SW118 was lower than the Lummi Nation fecal coliform bacteria geometric mean standard of 50 cfu/100 ml, the Total Maximum Daily Load (TMDL) target of 39 cfu/100 ml established for the lower Nooksack River (Ecology 2000, 2002), and the 90th Percentile standard of 100 cfu/100 ml. In 2012 sampling shows that fecal coliform densities are again on the rise in the Nooksack River. Although the geometric mean was achieved at Site SW018/SW118 during 2012 the value nearly doubled compared with 2011, while the 90th percentile more than tripled far exceeding the 90th percentile Class AA freshwater quality standard. Therefore, the water quality standard was not achieved at the Nooksack River during 2012 and the designated uses are not being supported.

Figure 6.14 depicts the 30 sample running geometric mean and 90th percentile of fecal coliform bacteria for Site SW030 in Bellingham Bay between the Nooksack River Delta and Portage Bay. The fecal coliform bacteria sample results for this representative Class A marine water site have been similar to the results from SW018/SW118 over the period of record. During 1998 through 2003, there was a general trend of decreasing fecal coliform bacteria density. Similar to the Nooksack River site (SW018/SW118), fecal coliform bacteria levels at the Bellingham Bay near shore site (SW030) increased from 2004 to 2009 and began to improve in 2010. Sample Site SW030 met the geometric mean standard during 2011, but the 90 percentile value was above the standard. During 2012 the geometric mean at Site SW030 nearly tripled and the 90th percentile was more than 6 times higher than in 2011. Therefore, neither the geometric mean nor the 90th percentile standard was achieved at Site SW030 during 2012 and the designated uses are not being supported. The increasing trend of fecal coliform bacteria in the Nooksack River and Bellingham Bay is a sign that water quality in the Nooksack River watershed and Bellingham Bay are again being diminished after several years of low bacteria densities and improved water quality.

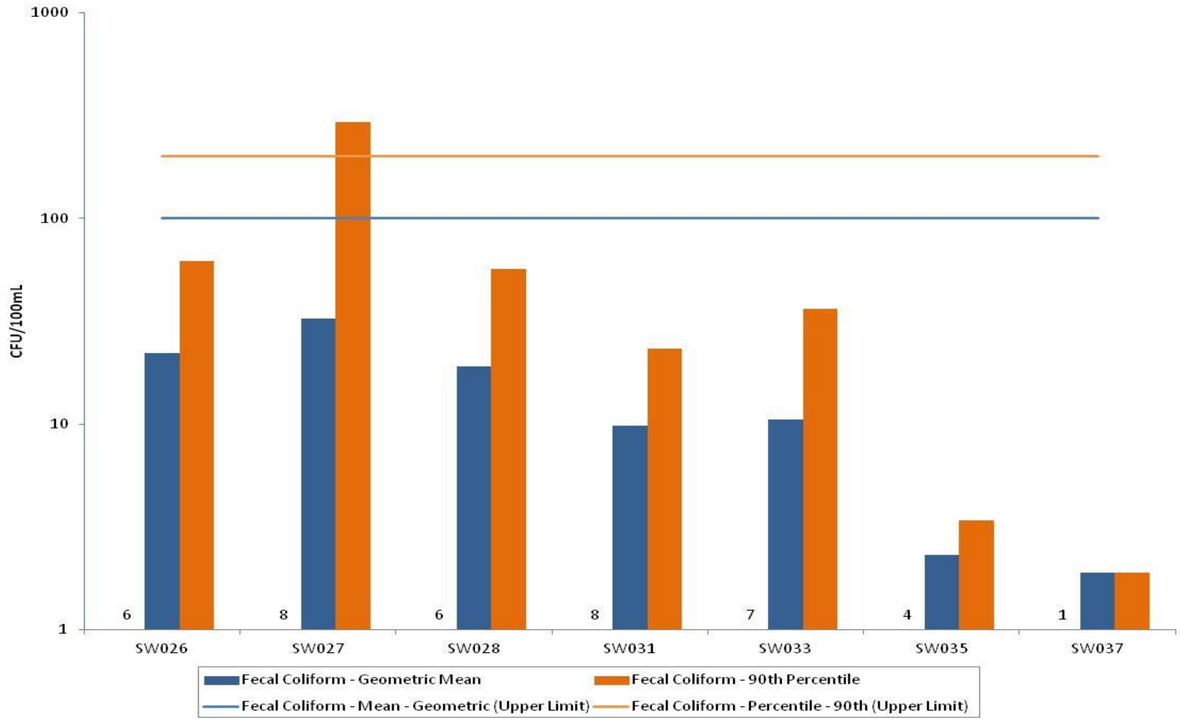

Figure 6.8 Class A Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2012

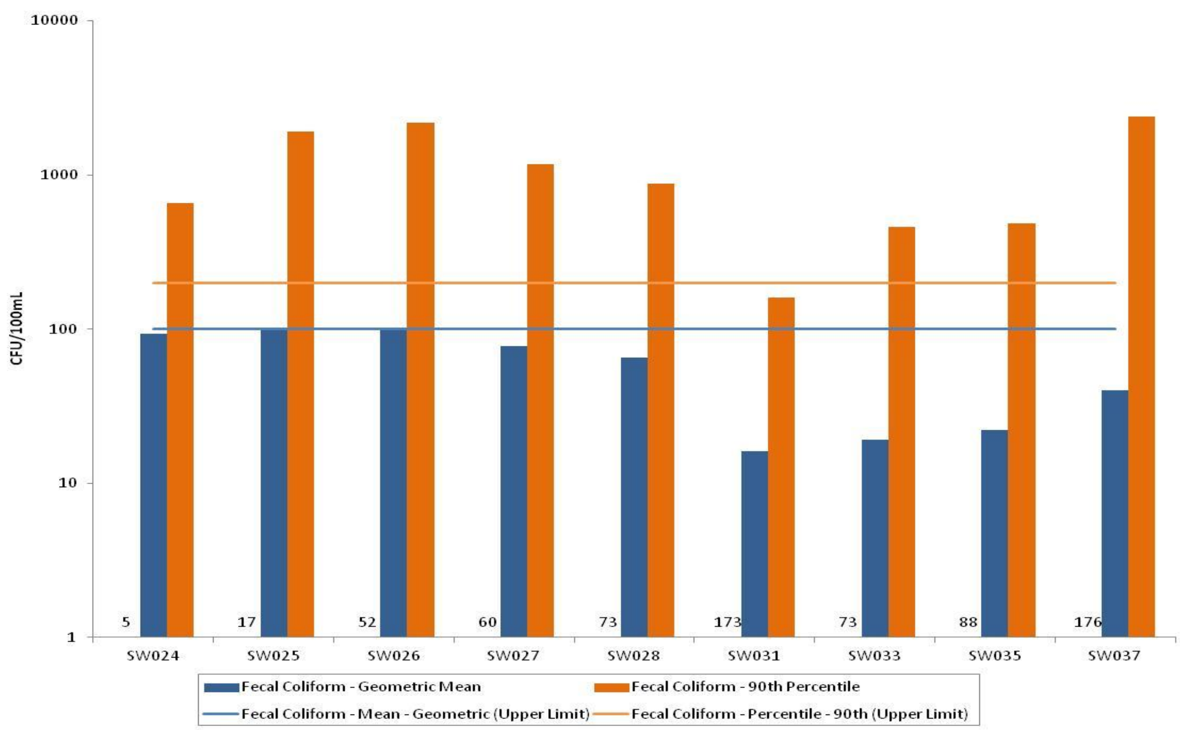

Figure 6.9 Class A Freshwater Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

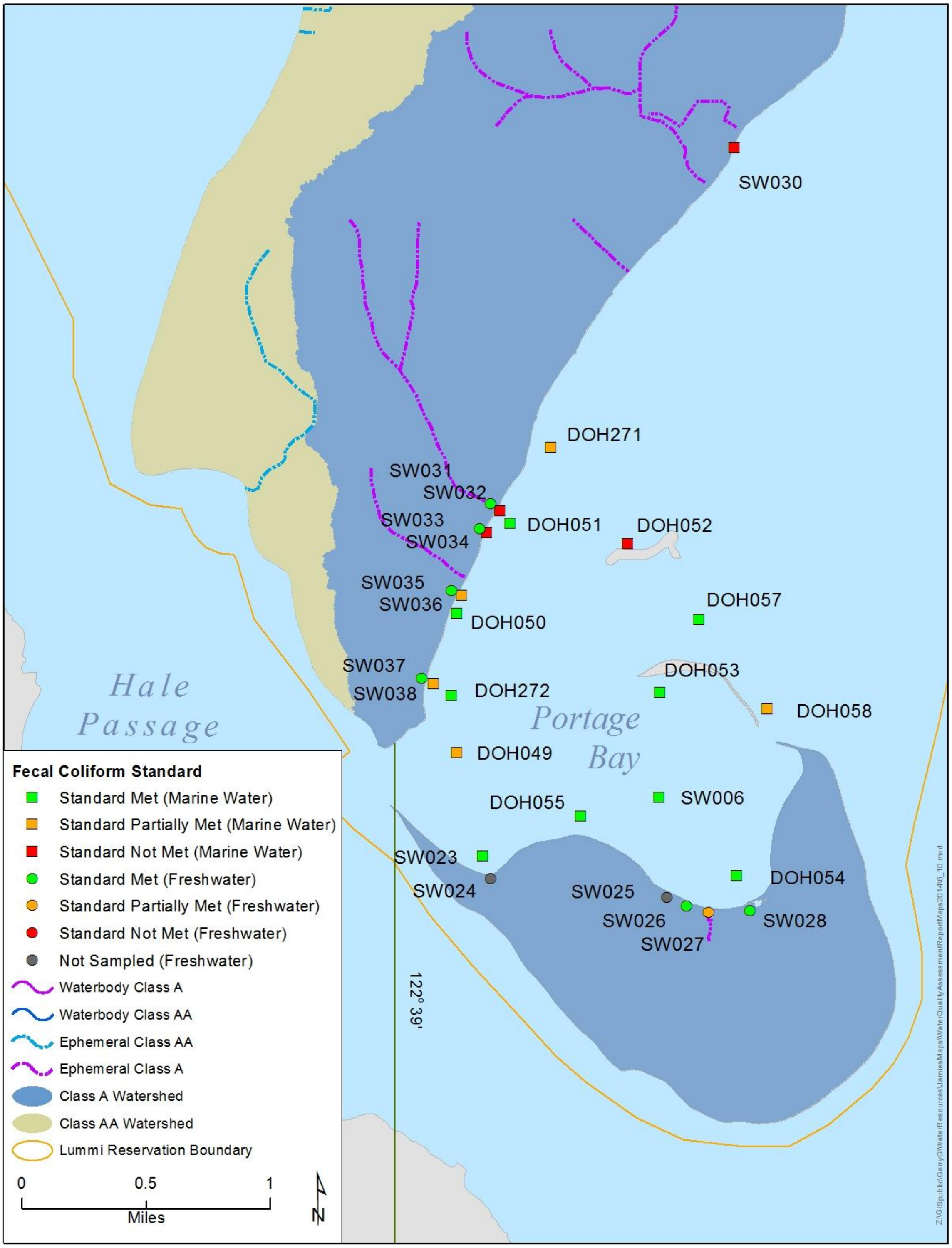

Figure 6.10 Class A Freshwater and Marine Water Fecal Coliform Compliance with Water Quality Standards: 2012

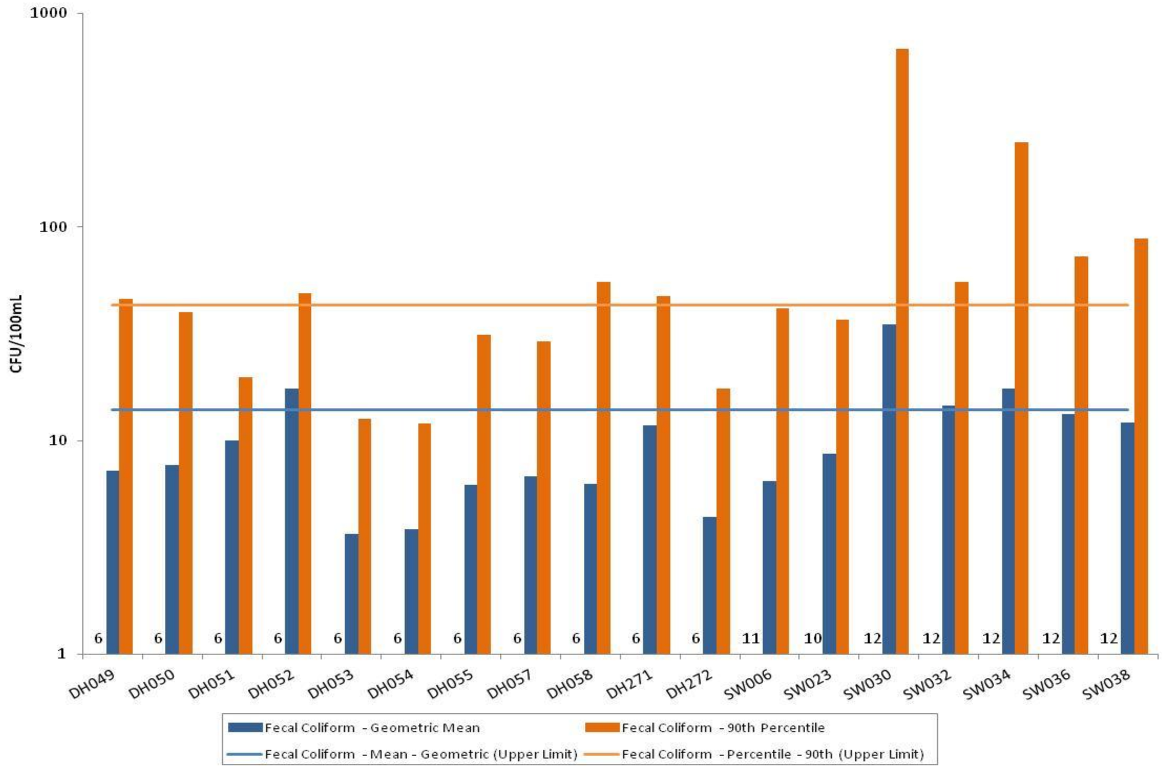

Figure 6.11 Class A Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: 2012

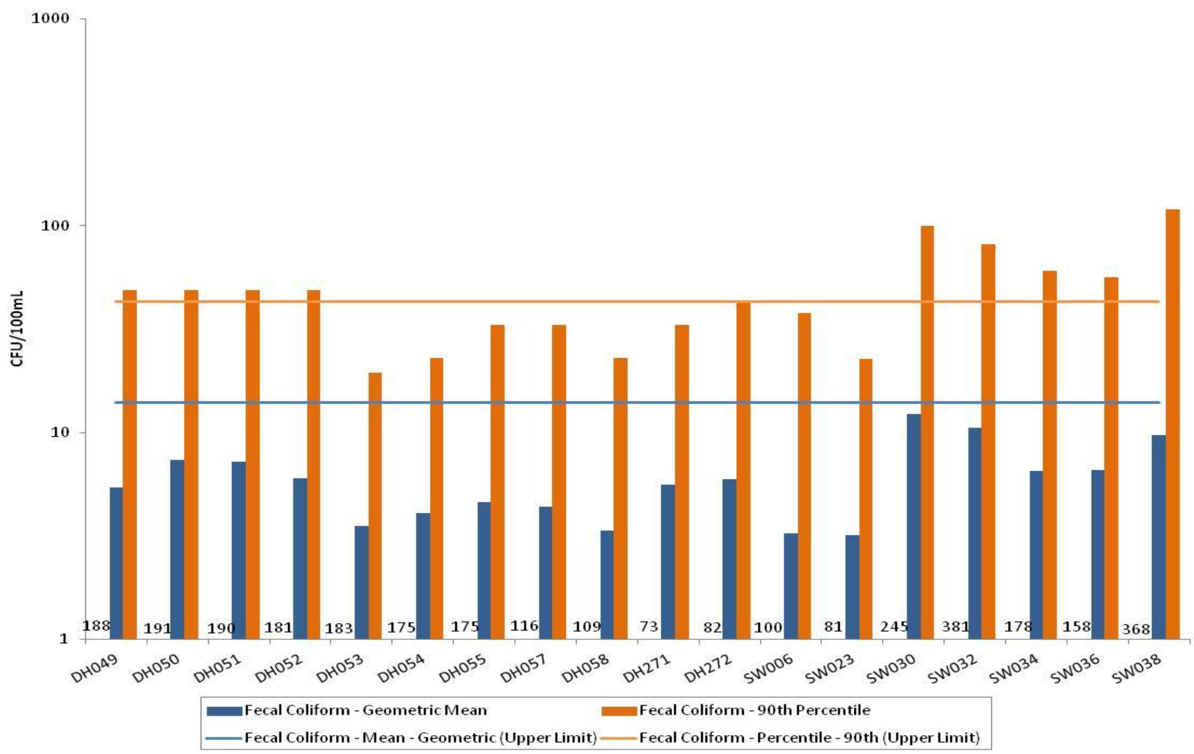

Figure 6.12 Class A Marine Water Fecal Coliform Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

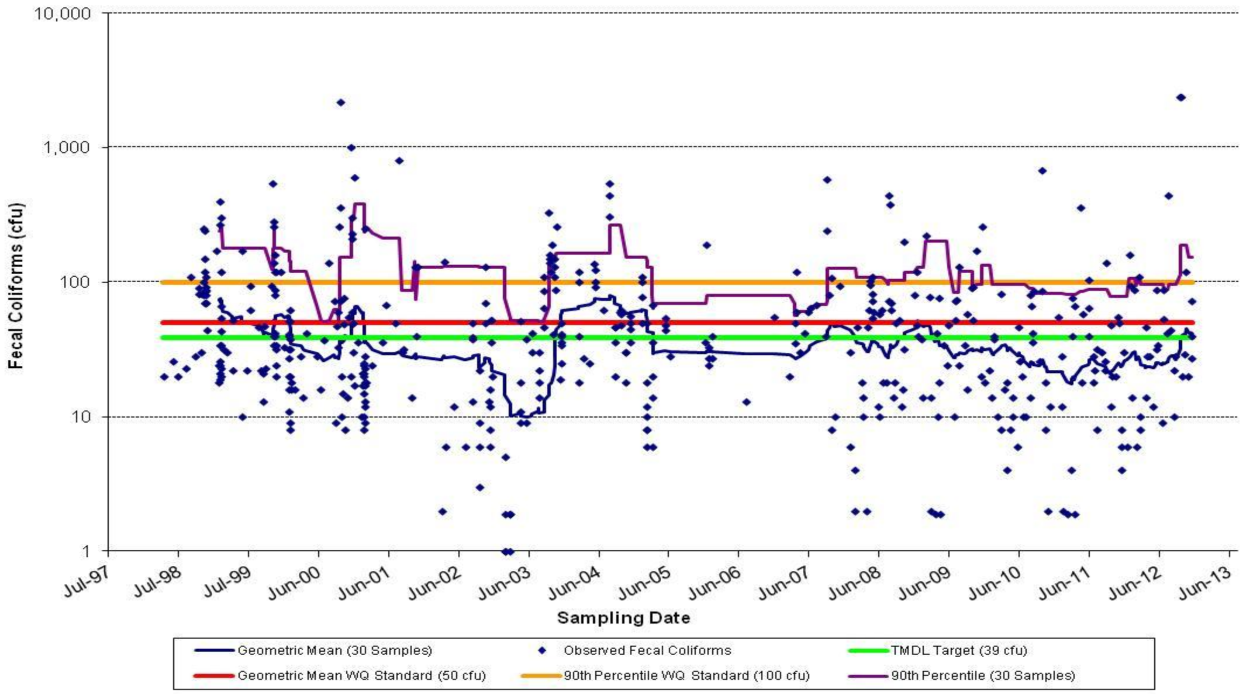

Figure 6.13 Class AA Freshwater Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW018/SW118 (Nooksack River)

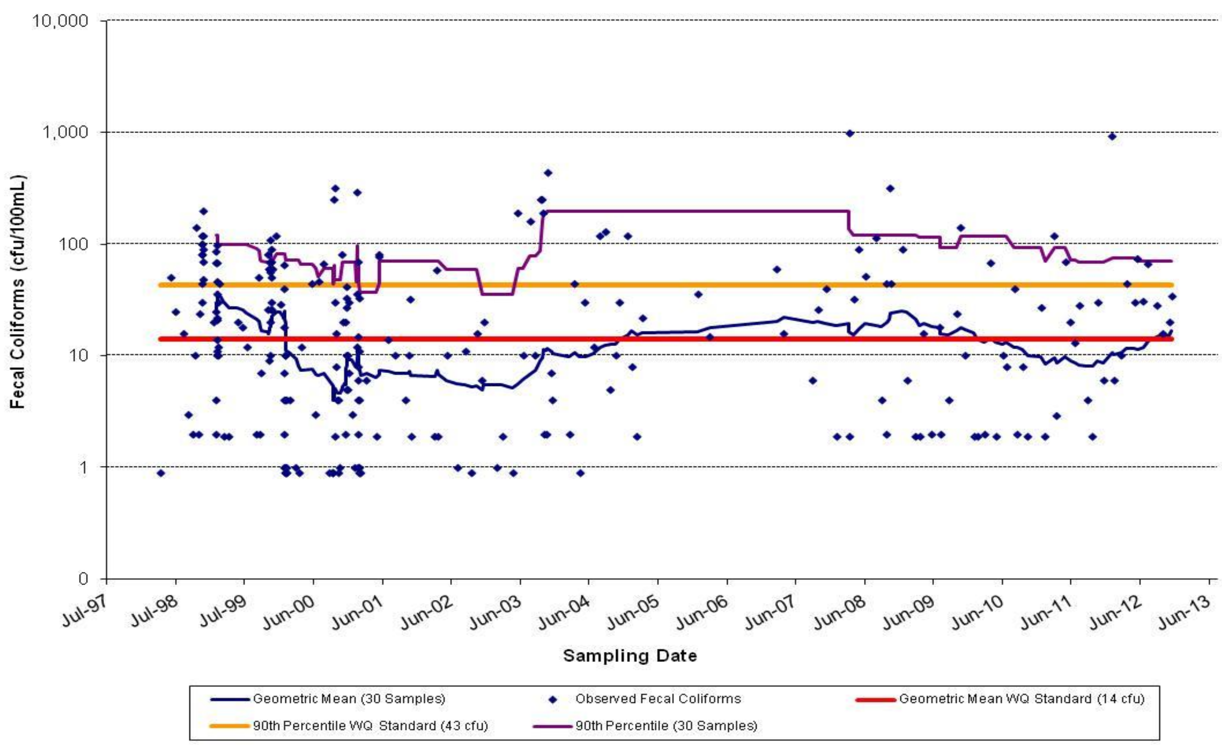

Figure 6.14 Class A Marine Water Fecal Coliform Bacteria Results – 30 Sample Running Geometric Mean and 90th Percentile at Site SW030

6.4.Enterococcus Results

As described in Section 6.1, collected water quality samples are transported on ice to a contracted analytical laboratory the day of collection and tested for fecal coliform bacteria, *E.coli*, and enterococcus. Water from one sample bottle is used for each of the tests; fecal coliform bacteria and *E. coli* are enumerated from the same growth plates.

6.4.1. Class AA Waters

The Class AA freshwater standards for enterococcus bacteria are a geometric mean not to exceed 33 cfu/100 ml and not exceed a single sample maximum allowable density of 61 cfu/100 ml. As shown in Figure 6.15 the geometric mean was below the standard at 10 of the 16 sample sites during 2012. However, as shown in Figure 6.17, both the geometric mean and the single sample maximum allowable density was only achieved at 1 of the 16 sites sampled during 2012. As shown in Figure 6.16, the geometric mean was below the standard at 8 of the 17 sample sites (data were included for discontinued Nooksack River site SW018) for the period of record through 2011. However, because the single maximum allowable density criterion was exceeded at all 17 sites, the water quality standard for enterococcus was not achieved at any of the Class AA freshwater sample sites for the period of record. The site with the highest geometric mean and single sample density percentile was Site SW009 located on the Lummi River at the Reservation boundary. Additional sites along the northern Reservation boundary (SW010, SW011, SW012, SW013, SW014, and SW017) had high geometric mean and single sample maximum allowable density values. Sample sites SW003 and SW058 are downstream from these sites along the boundary and also experienced high enterococcus counts.

The Class AA marine water standards for enterococcus are a geometric mean not to exceed 35 cfu/100 ml and not exceed a single sample maximum allowable density of 104 cfu/100 ml. As shown in Figure 6.18, only 5 of the 12 sample sites met these criteria during 2012. As shown in Figure 6.17, of the 7 sample sites that did not meet both the geometric mean and the single sample maximum allowable density, 4 of those sites achieved part of the standard. However as both the geometric mean and single sample maximum allowable density was only achieved at 5 of the 12 sample sites the water quality standard was not achieved at the remaining 7 Class AA marine water sites during 2012. All sample results at Sites SW002 had values too low for the laboratory to detect (10 cfu/100ml) for enterococcus during 2012. As shown in Figure 6.19, sites SW001, SW002, and SW022 met the criteria for the period of record. The site with the highest geometric mean and single sample maximum density value was Site SW008, which is located on the Lummi River where the river flows under Hillaire Road. Site SW008 is downstream from Site SW009 which is located along the northern Reservation boundary and has not achieved the water quality standard for enterococcus during the period of record.

As summarized in Table 6.1, the relation between fecal coliform bacteria and enterococcus bacteria varies by site and there is generally a poor relationship between the two types of bacteria. The best relationships, defined by the highest coefficient of determination (r^2) and slope of the best-fit line close to 1 was Sites SW003 (northern Lummi River distributary channel) and SW053 (Lummi Bay at northern Lummi River distributary channel tidegate).

At Sites SW003 and SW053, as fecal colifom bacteria values increased, enterococcus values increased. Because fecal coliform bacteria occur in human feces, but can also be present in animal feces, soil, and submerged wood and in other places outside the human body, and enterococcus are typically a more human-specific subgroup within the larger fecal coliform bacteria group, the very good relationship at these sites suggests that the source of fecal coliform bacteria is from human waste. The findings at Site SW003 and SW053 suggest a potential source of human waste in watershed “O” where these sites are located (Figure 2.2).

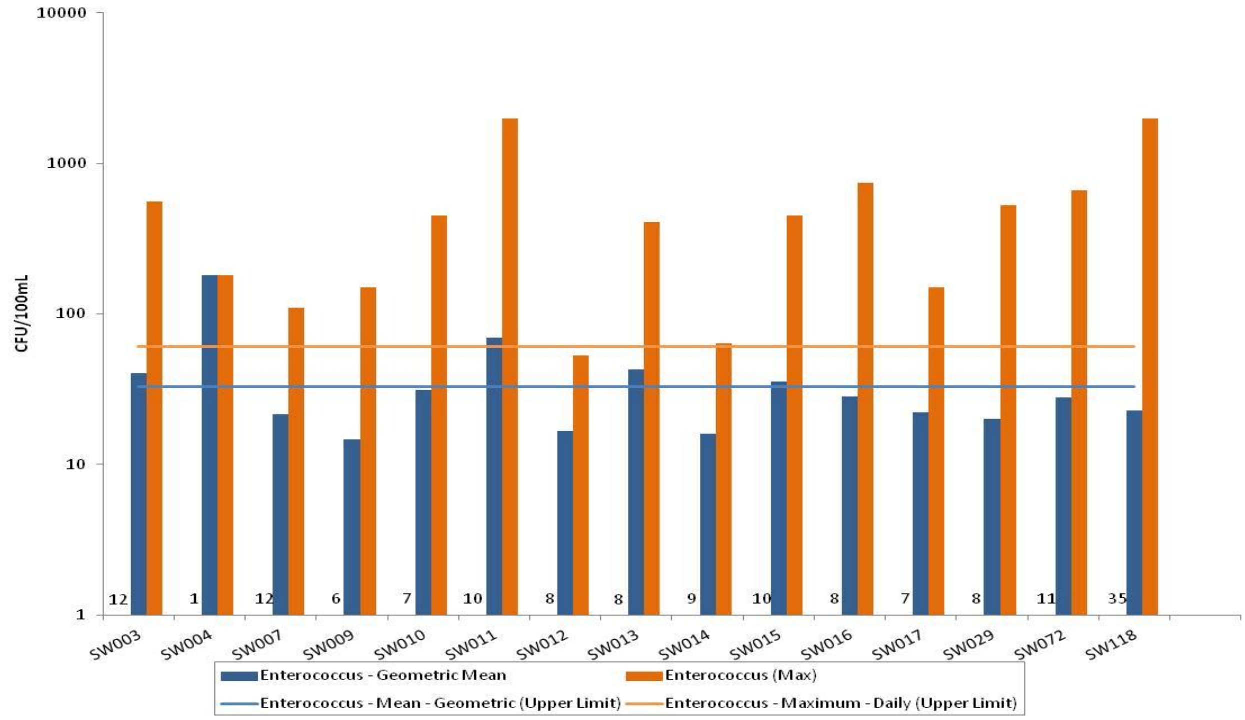

Figure 6.15 Class AA Freshwater Enterococcus Bacteria Results Compared with Water Quality Standards: 2012

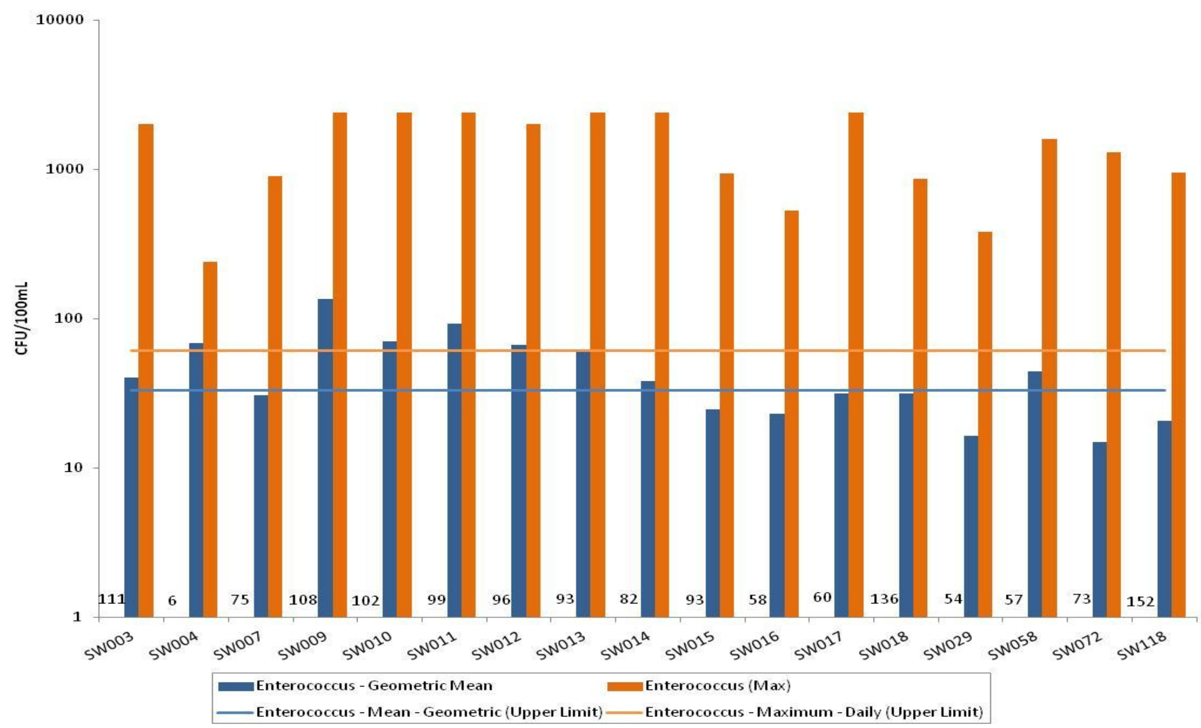

Figure 6.16 Class AA Freshwater Enterococcus Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

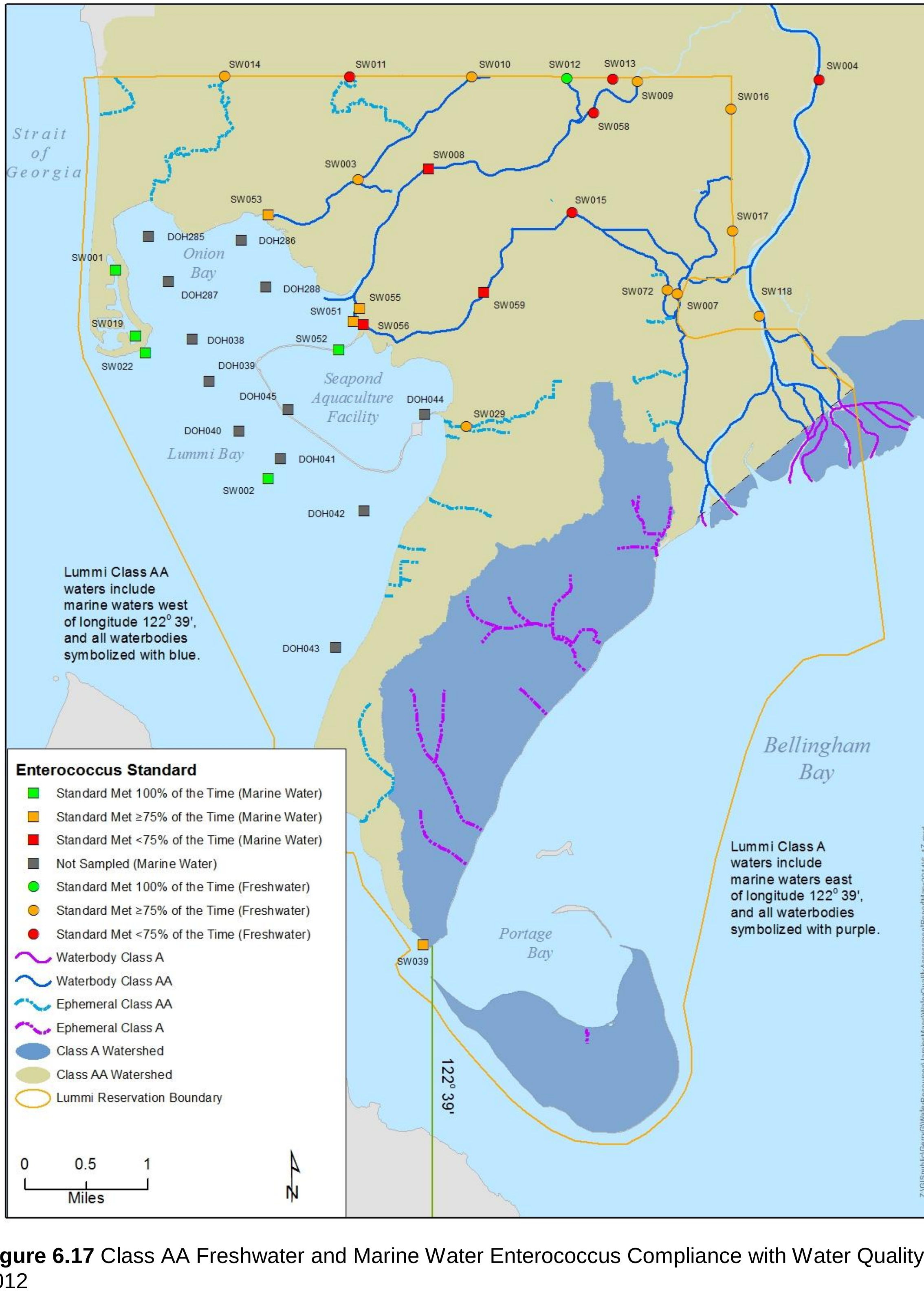

Figure 6.17 Class AA Freshwater and Marine Water Enterococcus Compliance with Water Quality Standards: 2012

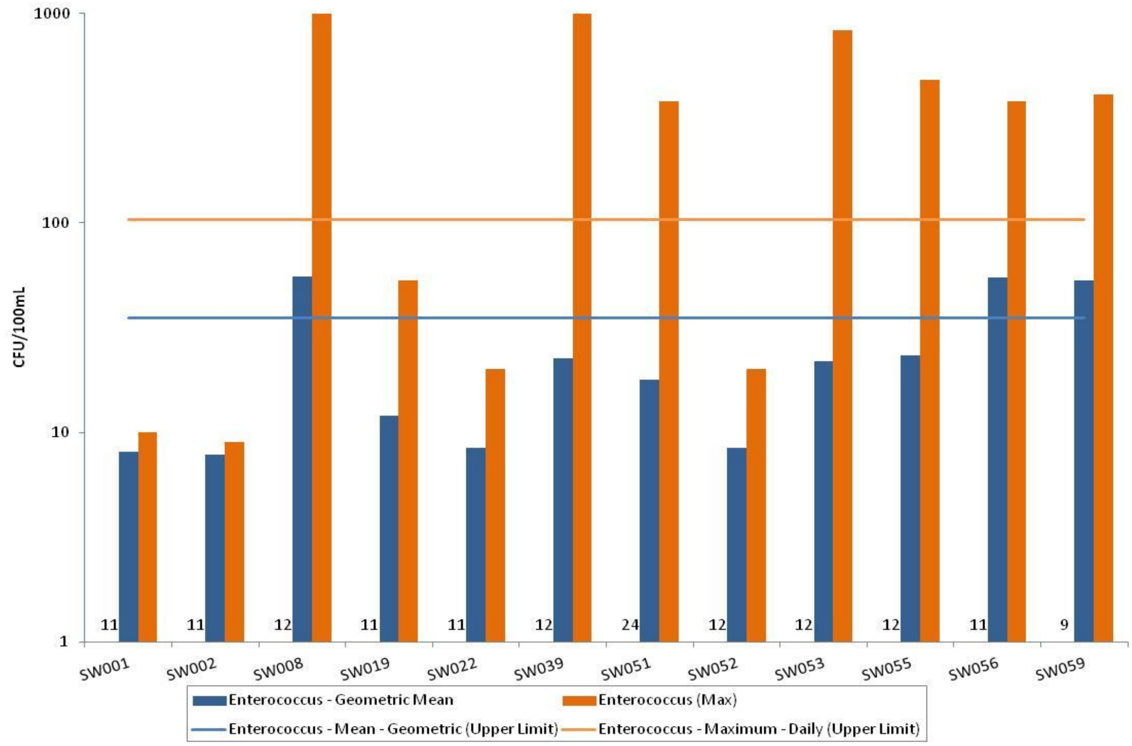

Figure 6.18 Class AA Marine Water Enterococcus Bacteria Results Compared with Water Quality Standards: 2012

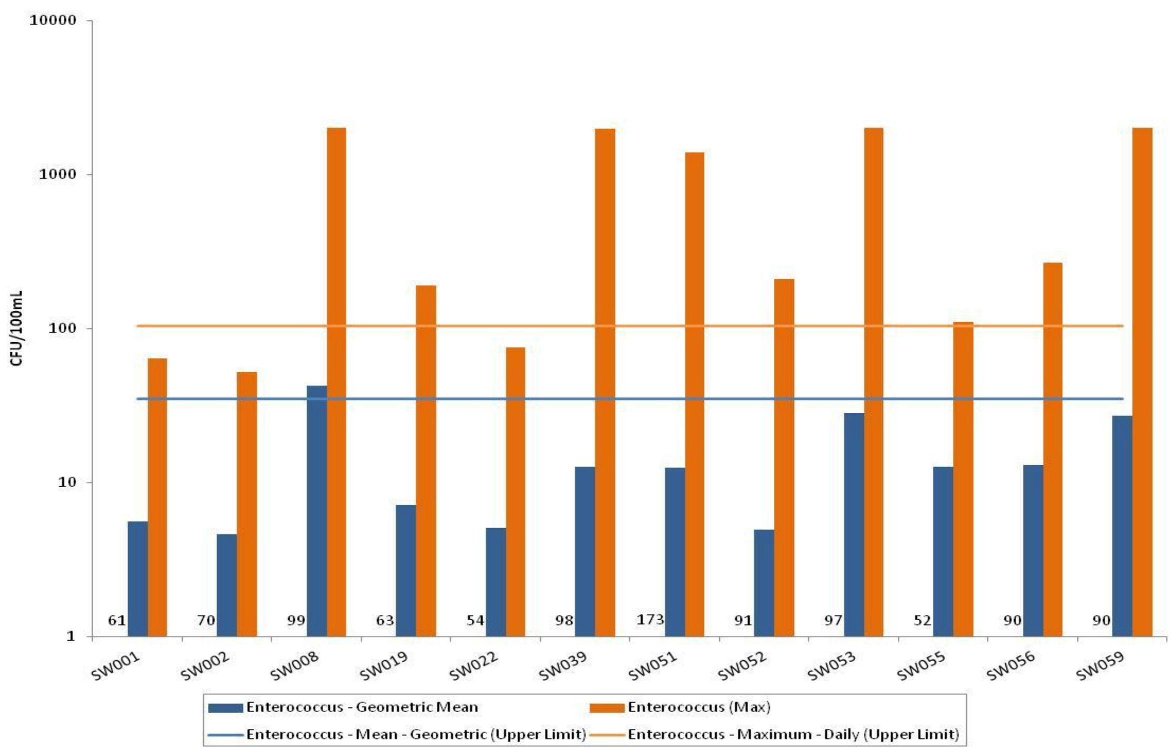

Figure 6.19 Class AA Marine Water Enterococcus Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

Table 6.1 Relation Between Fecal Coliform and Enterococcus Bacteria – Class AA Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW003	123	0.76	37.61	0.68
SW007	87	0.96	18.73	0.46
SW009	114	1.29	49.46	0.42
SW010	109	0.79	18.77	0.58
SW011	109	1.34	64.15	0.41
SW012	104	2.15	-11.66	0.62
SW013	100	0.14	95.03	0.10
SW014	91	0.42	129.32	0.27
SW015	105	0.58	50.71	0.22
SW016	65	0.38	21.36	0.20
SW017	67	0.77	-19.71	0.53
SW029	62	2.94	-6.26	0.48
SW058	57	0.62	136.60	0.11
SW072	83	0.12	51.98	0.04
SW118	191	1.69	9.53	0.48
Marine Water				
SW001	72	0.49	-0.35	0.54
SW002	81	0.23	1.66	0.12
SW008	111	1.83	22.30	0.57
SW019	74	0.16	3.57	0.22
SW022	65	0.53	-0.57	0.57
SW039	111	0.08	9.58	0.38
SW051	196	0.08	32.60	0.01
SW052	103	0.14	2.44	0.14
SW053	108	0.70	5.64	0.68
SW055	64	3.84	-48.39	0.73
SW056	101	0.58	41.07	0.05
SW059	99	0.68	46.65	0.54

6.4.2. Class A Waters

The Class A freshwater standards for enterococcus bacteria include a geometric mean not to exceed 33 cfu/100 ml and not to exceed a single sample maximum allowable density of 61 cfu per 100 ml. As shown in Figure 6.20, the geometric mean was below the standard at sample sites SW026, SW028, SW031, SW033, SW035, and SW037 in 2012. As shown in Figure 6.22 the water quality standard was achieved at 6 of the 7 Class A freshwater sites sampled during 2012. As shown in Figure 6.21, the geometric mean was below the standard at eight of the nine sample sites for the period of record through 2011. However, because the single sample criteria were exceeded at eight of the nine sites, the water quality standard for enterococcus was only achieved at Site SW024 for the period of record. It is noted that the results collected at Site SW024 reflect the laboratory findings from only two samples. The site with the highest geometric mean and single sample value during 2012 was SW027, which drains a forested wetland on Portage Island. The site with the highest geometric mean and single sample value over the period of record is Site SW037, which is located along Hermosa Beach, a developed portion of the Lummi Peninsula.

The Class A marine water quality standards for enterococcus are a geometric mean not to exceed 35 cfu/100 ml and not to exceed a single sample maximum allowable density of 104 cfu/100 ml. As shown in Figure 6.23, the water quality standard was achieved at only 2 of the 7 sites sampled during 2012. As shown in Figure 6.22 the remaining 5 sites sampled achieved part of the water quality standard, however, as both the geometric mean and the single sample maximum allowable density were not achieved the water quality standard was not met for those sites during 2012. As shown in Figure 6.24, the geometric mean was lower than the standard at all sample sites but both criteria were not achieved for any of the sites for the period of record due to the exceedence of the single sample maximum density criteria.

As summarized in Table 6.2, the relation between fecal coliform bacteria and enterococcus bacteria varies by site and there is a generally poor relationship between the two types of bacteria. The best relationships, as defined by the highest coefficient of determination (r^2) and the slope of the best-fit line closest to 1, are Site SW036 and Site SW037 (along Lummi Peninsula/Portage Bay shoreline). There is a strong positive correlation between fecal coliform bacteria and enterococcus bacteria at Site SW036 and Site SW037, as fecal coliform bacteria values increased enterococcus values increased. As described in section 6.2.1, a positive correlation between fecal coliform and enterococcus indicates that the source of fecal coliform at Site SW036 and Site SW037 is from human waste.

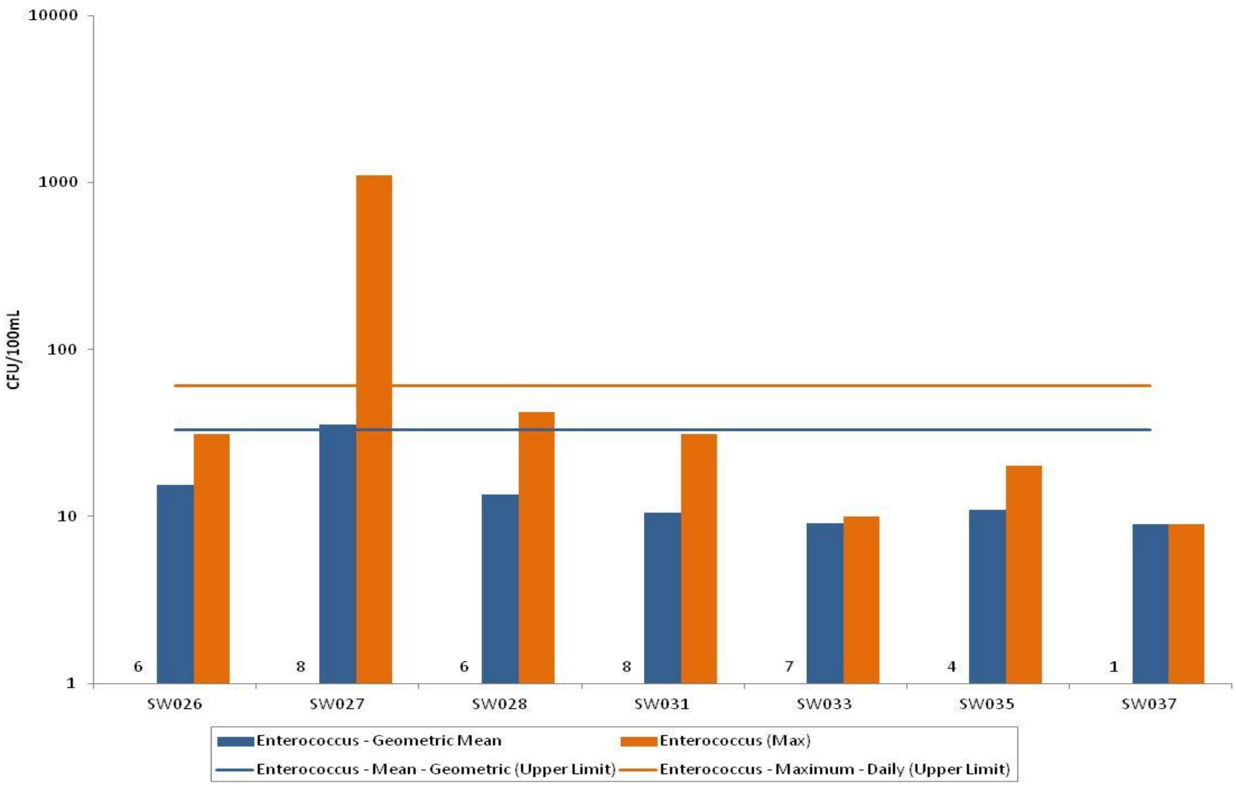

Figure 6.20 Class A Freshwater Enterococcus Results Compared with Water Quality Standards: 2012

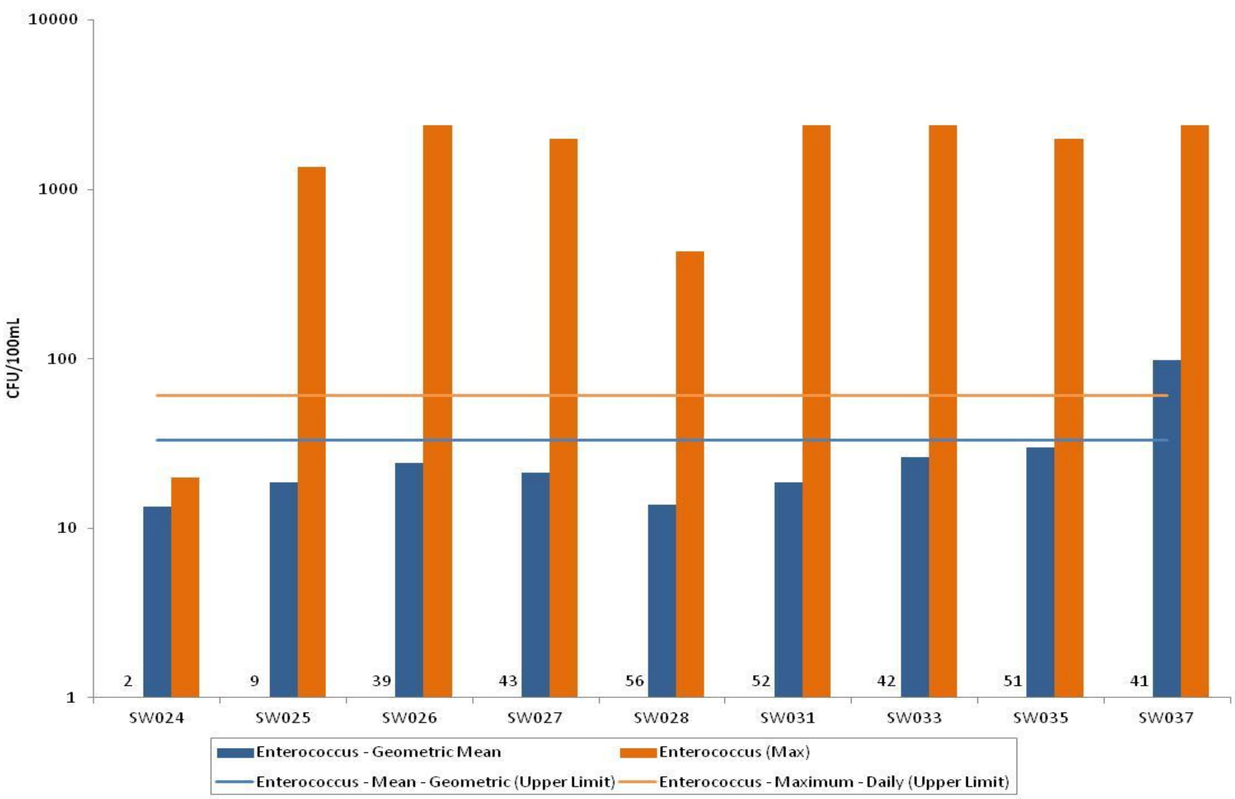

Figure 6.21 Class A Freshwater Enterococcus Results Compared with Water Quality Standards: Period of Record through 2011

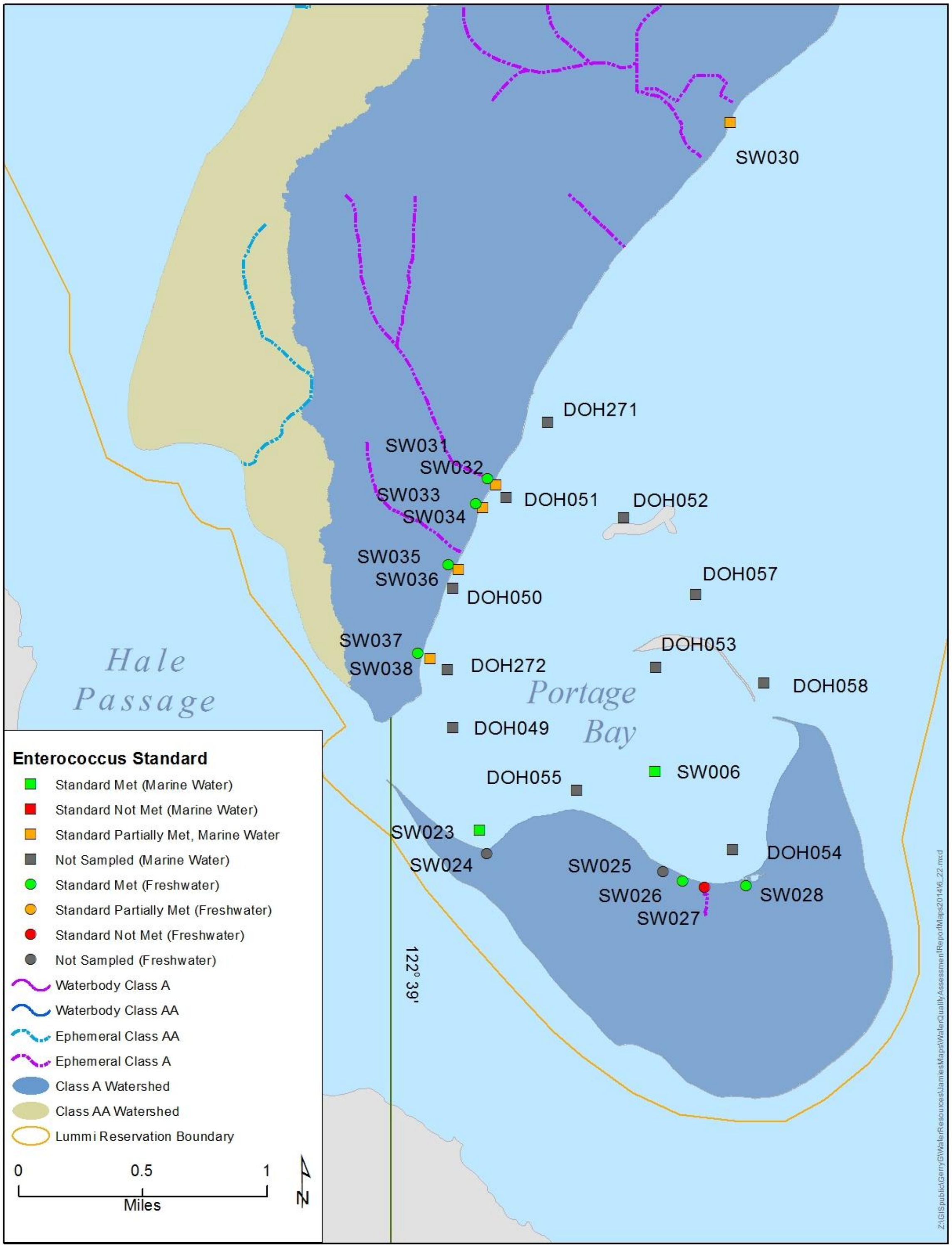

Figure 6.22 Class A Freshwater and Marine Water Enterococcus Compliance with Water Quality Standards: 2012

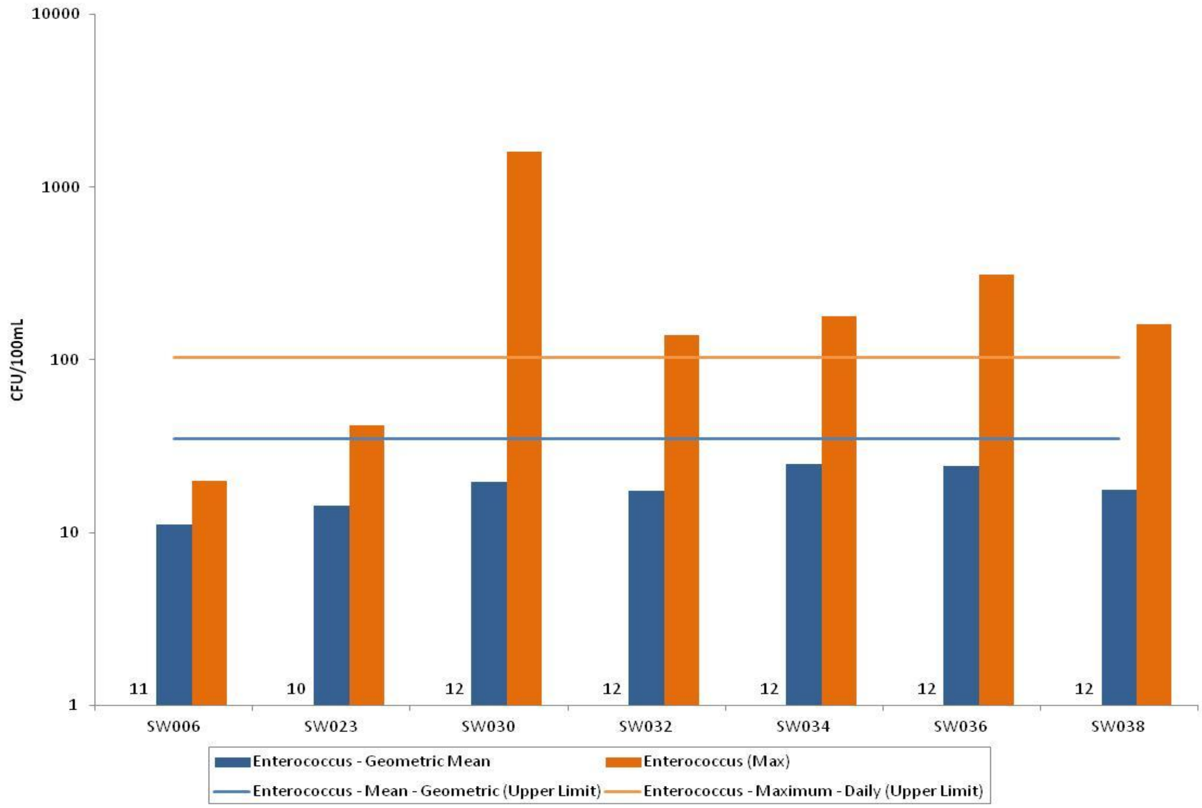

Figure 6.23 Class A Marine Water Enterococcus Results Compared with Water Quality Standards: 2012

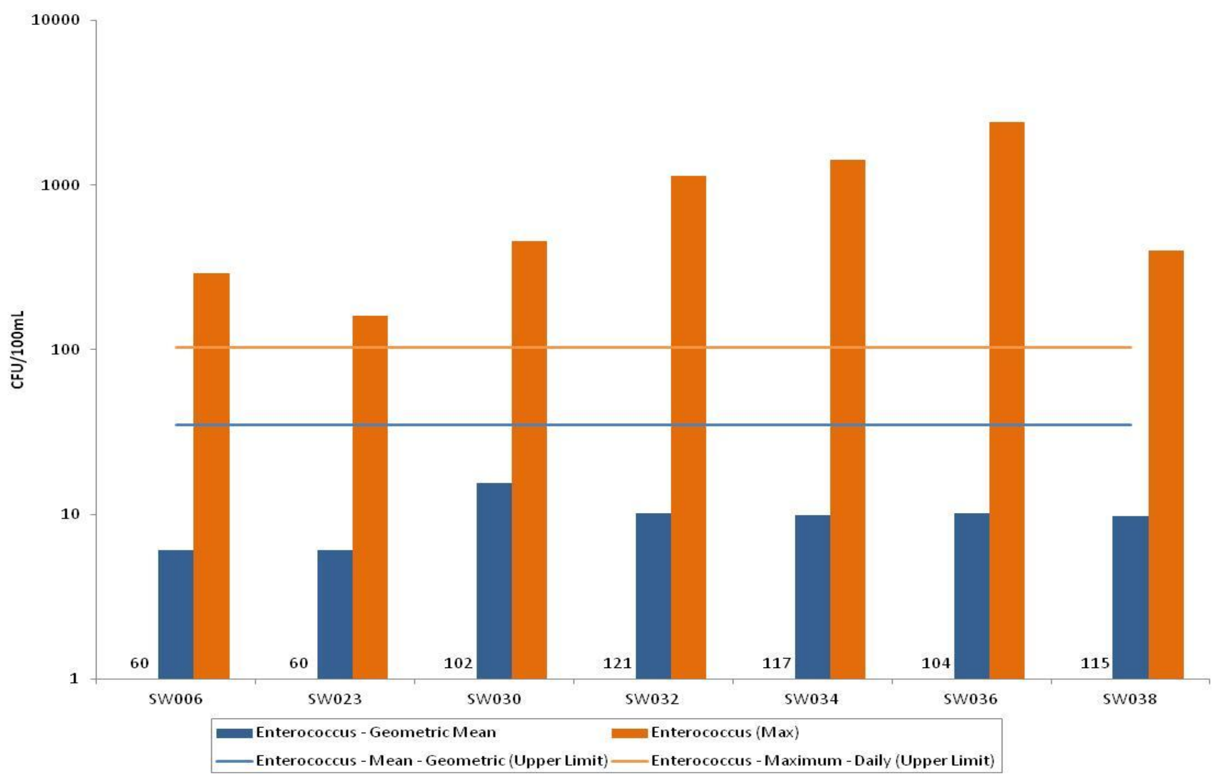

Figure 6.24 Class A Marine Water Enterococcus Bacteria Results Compared with Water Quality Standards: Period of Record through 2011

Table 6.2 Relation Between Fecal Coliform and Enterococcus Bacteria – Class A Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW025	10	1.22	127.76	0.75
SW026	45	3.46	333.66	0.47
SW027	51	0.21	278.66	0.01
SW028	62	11.04	-110.58	0.61
SW031	60	0.48	11.09	0.70
SW033	49	0.14	86.63	0.61
SW035	53	1.19	-29.84	0.66
SW037	42	2.67	-630.31	0.96
Marine Water				
SW006	71	0.23	4.37	0.30
SW023	70	0.65	0.88	0.69
SW030	116	0.56	30.25	0.32
SW032	133	0.55	6.17	0.69
SW034	129	0.41	8.75	0.53
SW036	116	1.09	-12.07	0.99
SW038	126	0.35	6.75	0.55

6.5. Escherichia coli Results

As described in Section 6.1, collected water quality samples are transported on ice to a contracted analytical laboratory the day of collection and water from one sample bottle is used for each of the tests for bacteria; fecal coliform bacteria and *Escherichia coli* (*E. coli*) are enumerated from the same growth plates.

Escherichia coli (*E. coli*) is a type of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. The Lummi Nation did not establish a water quality standard for *E. coli*, primarily because fecal coliform bacteria is the criterion used to classify commercial shellfish beds in the federal Food and Drug Administration (FDA) National Shellfish Sanitation Program (NSSP). Although there is currently not an adopted water quality standard for *E. coli*, the Program samples for *E. coli* since the EPA recommends *E. coli* as the best indicator of health risk from water contact in recreational waters and because an *E. coli* standard might be adopted in the future.

6.5.1. Class AA Waters

As summarized in Table 6.3, the fecal coliform bacteria results are generally highly correlated (coefficients of determination greater than 0.90 and slope of the best-fit line close to 1) with the *E. coli* results. The generally high correlations are not surprising since *E. coli* is a species in the fecal coliform bacteria group. The high correlation indicates that the measured fecal coliform bacteria levels are from fecal material from humans and other warm-blooded animals rather than from other bacteria types that are not necessarily fecal in origin (e.g., *Klebsiella*). Although still highly correlated with a coefficient of determination greater than 0.60, the correlation between fecal coliform bacteria and *E. coli* at sample sites SW002 and SW007 are lower and the deviation from a 1:1 slope of a best fit line is notably greater than for the majority of the other sites. Freshwater sample Sites SW003, SW010, SW014, SW017, SW029, SW118 and marine water sample Sites SW055 and SW056 had perfect correlation between fecal coliform bacteria and *E. coli* indicating that the *E. coli* are likely to be from bacteria types that are fecal in origin.

The high correlation is reflected in similar trends of fecal coliform bacteria and *E. coli* densities at the majority of sample sites. As shown in Figure 6.25 and Figure 6.26, the Class AA freshwater sites with the highest geometric mean and 90th percentile values were sites SW003, SW009, SW010, SW011, and SW012 along the northern Lummi River distributary channel and northern Reservation boundary. As shown in Figure 6.27 and Figure 6.28, the Class AA marine sites with the highest geometric mean and 90^{th} percentile values were sites SW008, SW053, SW056, and SW059. Sample Site SW008 is downstream from Site SW009 on the Lummi River but is classified as a marine water site. Although the *E. coli* density at Site SW053 is high, it is lower than the respective upstream Site SW003.

Table 6.3 Relation Between Fecal Coliform Bacteria and *E. coli* – Class AA Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW003	161	1.00	2.51	1.00
SW007	125	0.99	13.61	0.79
SW009	153	1.00	15.81	0.99
SW010	156	1.00	7.39	1.00
SW011	151	1.02	6.33	0.99
SW012	143	0.99	22.03	0.99
SW013	142	0.99	5.19	0.99
SW014	126	1.00	4.63	1.00
SW015	136	1.01	2.30	0.98
SW016	89	0.99	8.23	0.97
SW017	88	1.00	1.52	1.00
SW029	187	1.00	3.05	1.00
SW058	63	1.05	24.35	0.92
SW072	83	1.00	2.42	0.98
SW118	191	1.01	2.58	1.00
Marine Water				
SW001	73	0.97	0.49	0.81
SW002	96	0.96	0.63	0.62
SW008	150	1.01	5.92	0.99
SW019	88	0.88	0.90	0.76
SW022	79	0.99	0.39	0.94
SW039	197	1.00	0.98	0.99
SW051	220	1.09	0.18	0.94
SW052	114	1.00	0.11	0.99
SW053	127	1.00	2.69	0.99
SW055	64	1.00	0.51	1.00
SW056	109	1.00	0.56	1.00
SW059	103	0.99	3.55	0.99

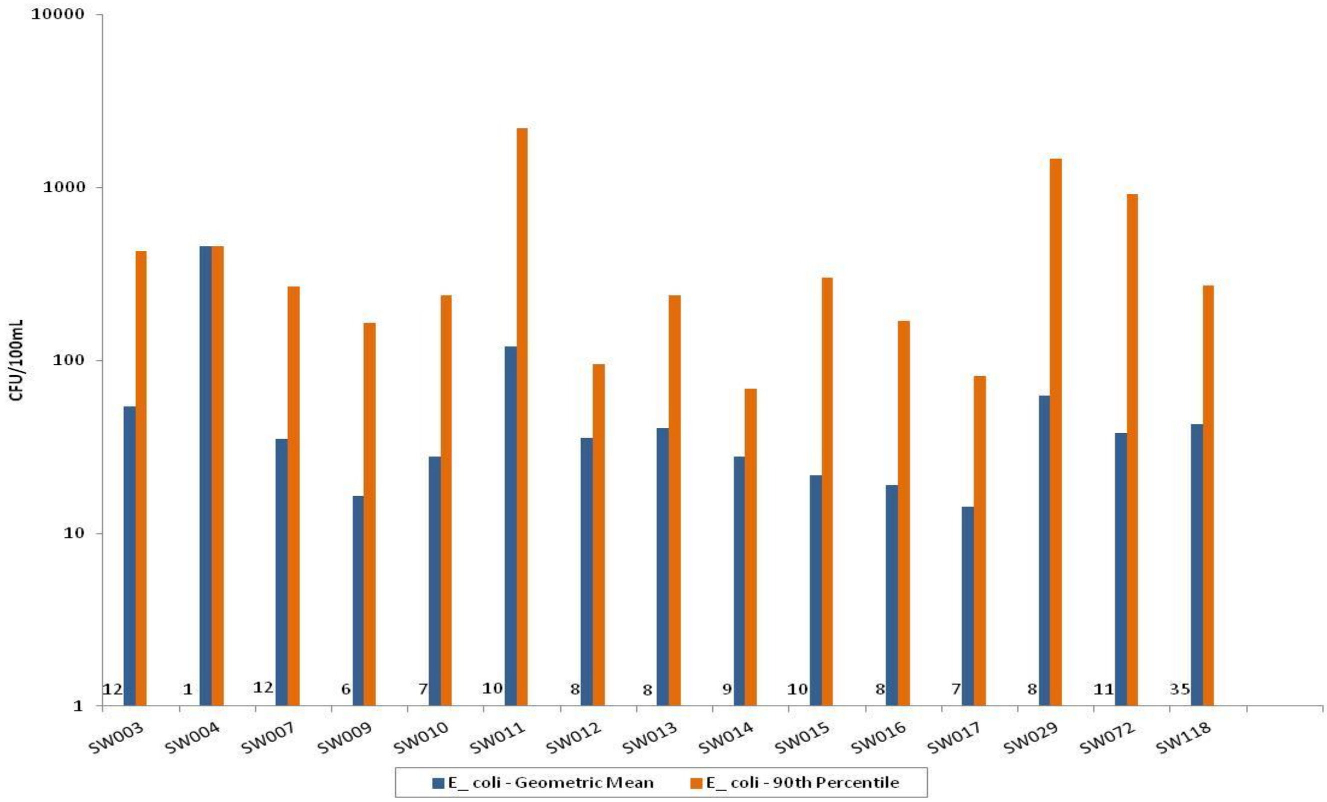

Figure 6.25 Class AA Freshwater *E.coli* Results: 2012

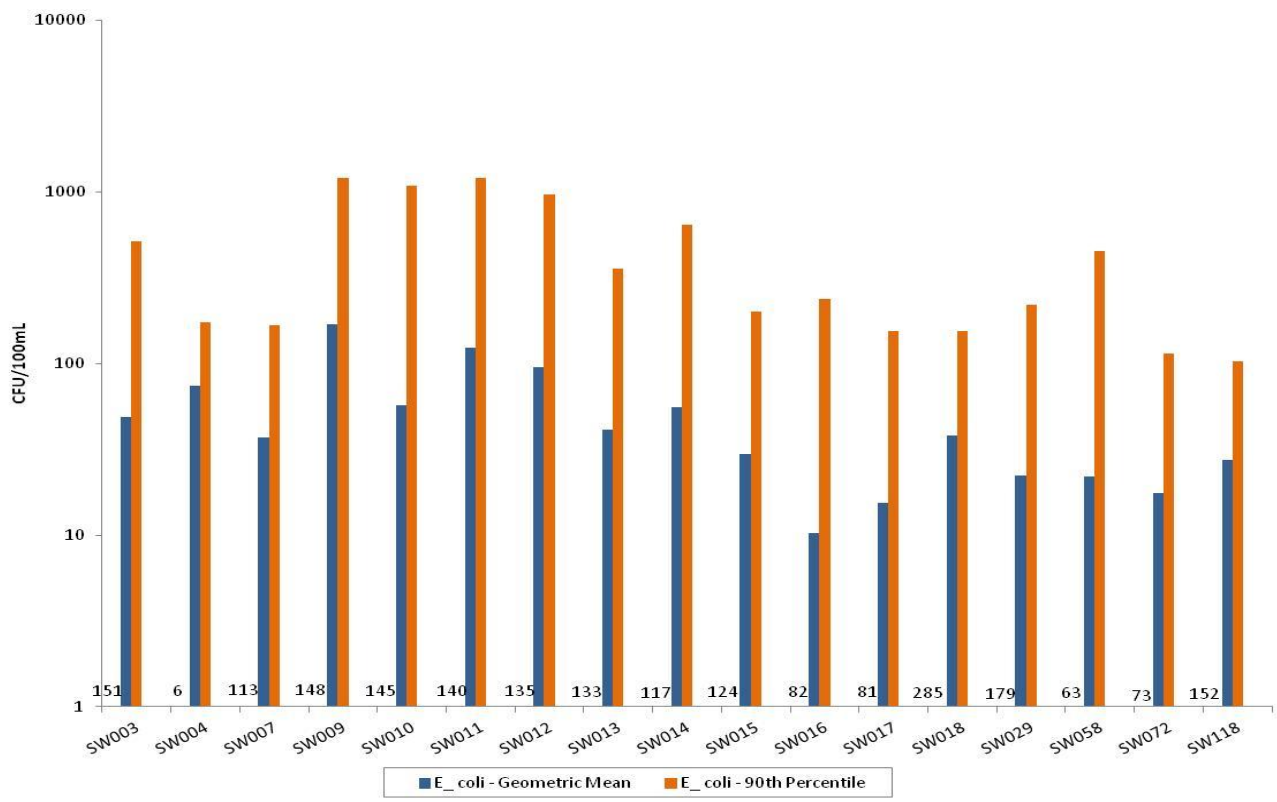

Figure 6.26 Class AA Freshwater *E.coli* Results: Period of Record through 2011

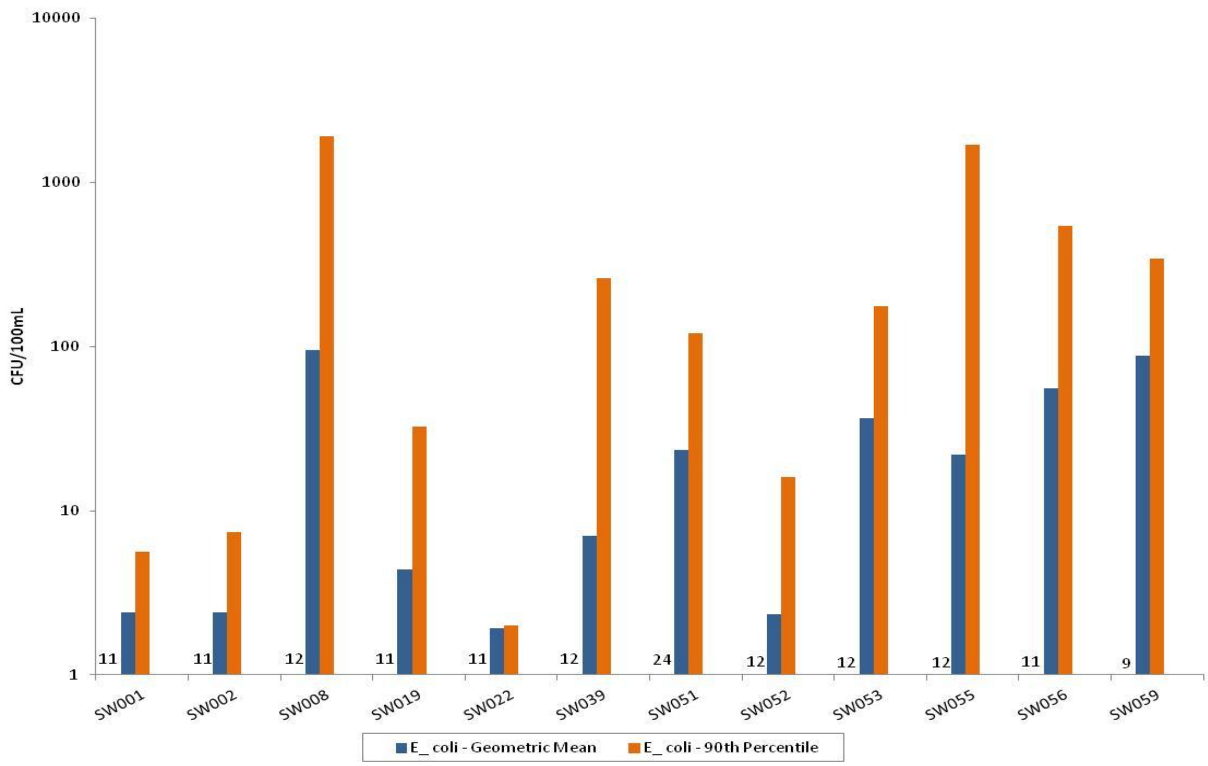

Figure 6.27 Class AA Marine Water *E.coli* Results: 2012

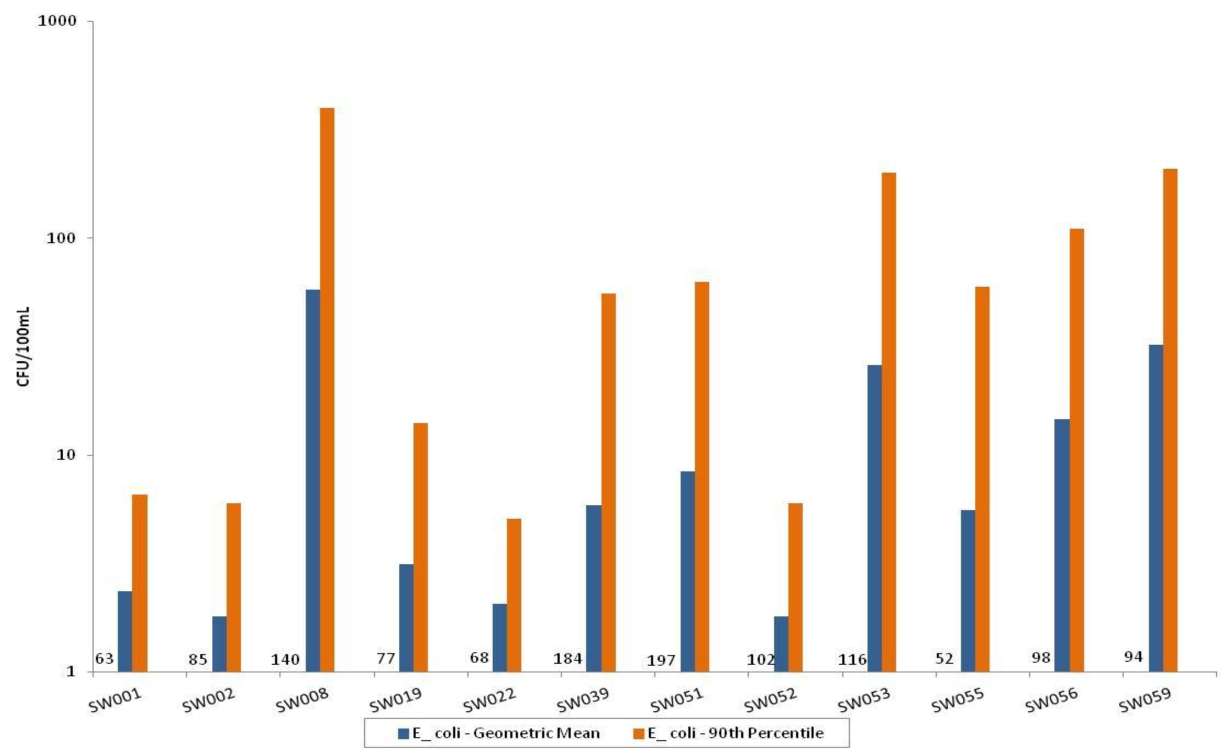

Figure 6.28 Class AA Marine Water *E.coli* Results: Period of Record through 2011

6.5.2. Class A Waters

As summarized in Table 6.4, the fecal coliform bacteria results for Class A waters were highly correlated (coefficients of determination greater than 0.90 and slope of the best-fit line close to 1) with the *E. coli* results. As described in section 6.3.1, the generally high correlations are not surprising since *E. coli* is a species in the fecal coliform bacteria group. The high correlation indicates that the fecal coliform bacteria are from fecal material from humans and other warm-blooded animals rather than from other bacteria types that are not necessarily fecal in origin (e.g., *Klebsiella*). Sample Site SW030 (in Bellingham Bay) has the poorest relationship between fecal coliform bacteria and *E.coli* with a coefficient of determination of 0.71 and slope of 0.49.

The generally high correlation between fecal coliform bacteria and *E.coli* is reflected in similar trends of fecal coliform bacteria and *E.coli* densities at sample sites. As shown in Figure 6.29, the Class A freshwater sites with the highest geometric means and 90^{th} percentiles during 2012 are Sites SW026, SW027, and SW028 located on Portage Island. Figure 6.30 illustrates, the Class A freshwater sites with the highest geometric means and 90^{th} percentiles over the period of record are located on Portage Island (SW024, SW025, SW026, SW027, and SW028) with an additional Site SW037 located along the Lummi Peninsula/Portage Bay Shoreline. As shown in Figure 6.31 Sites SW006 and SW023 respectively located in Portage Bay and Lummi Bay had the lowest geometric mean and 90th percentile for Class A marine water sites during 2012. In contrast, as shown in Figure 6.32, Site SW038 has one of the highest geometric mean and 90^{th} percentile for a Class A marine water for the period of record.

Table 6.4 Relation Between Fecal Coliform Bacteria and *E.coli* – Class A Waters

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW025	18	0.98	67.78	0.98
SW026	58	1.00	0.00	1.00
SW027	67	1.00	25.97	0.99
SW028	81	0.98	8.93	0.96
SW031	180	1.00	-0.51	1.00
SW033	78	1.00	0.44	1.00
SW035	87	1.00	2.24	1.00
SW037	171	1.00	15.58	1.00
Marine Water				
SW006	98	0.99	0.10	1.00
SW023	95	1.00	0.16	0.99
SW030	257	0.71	15.66	0.49
SW032	405	1.00	17.17	0.99
SW034	198	0.99	0.23	0.99
SW036	168	1.00	0.05	1.00
SW038	391	1.00	1.66	1.00

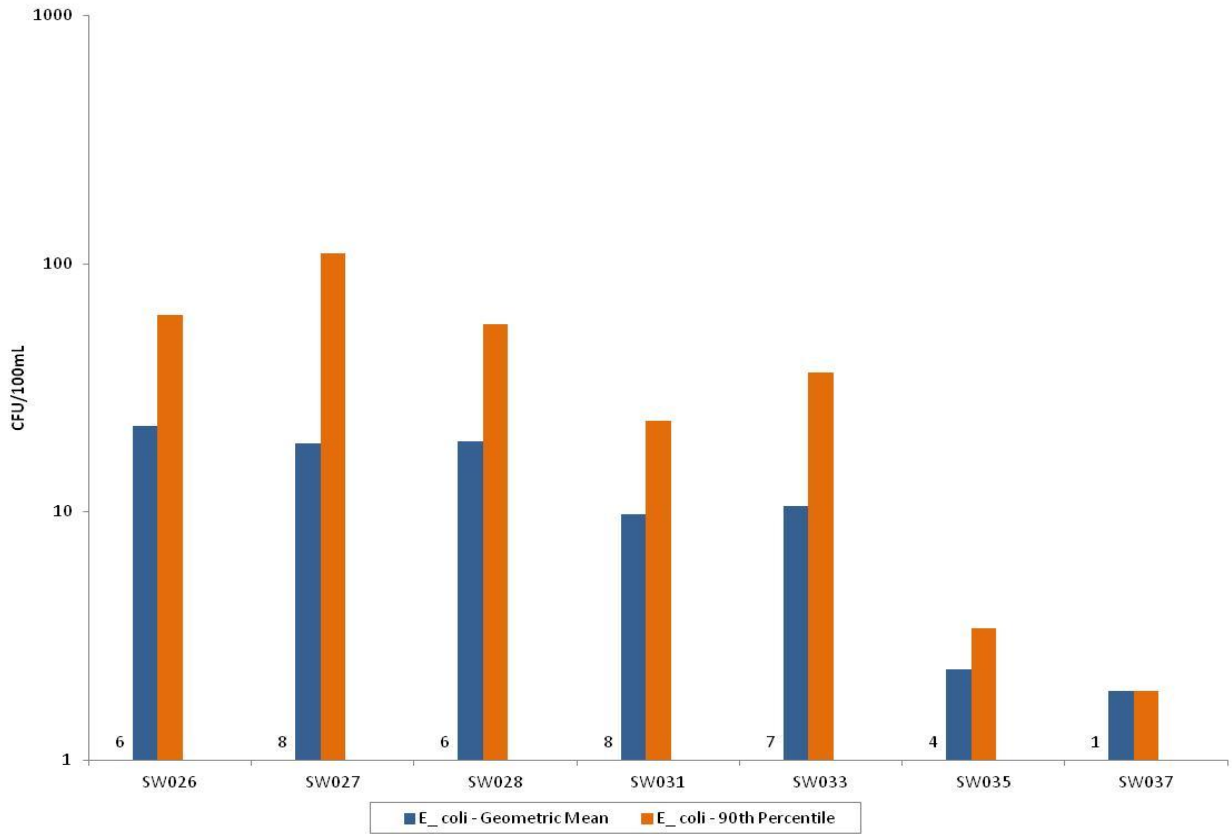

Figure 6.29 Class A Freshwater *E.coli* Results: 2012

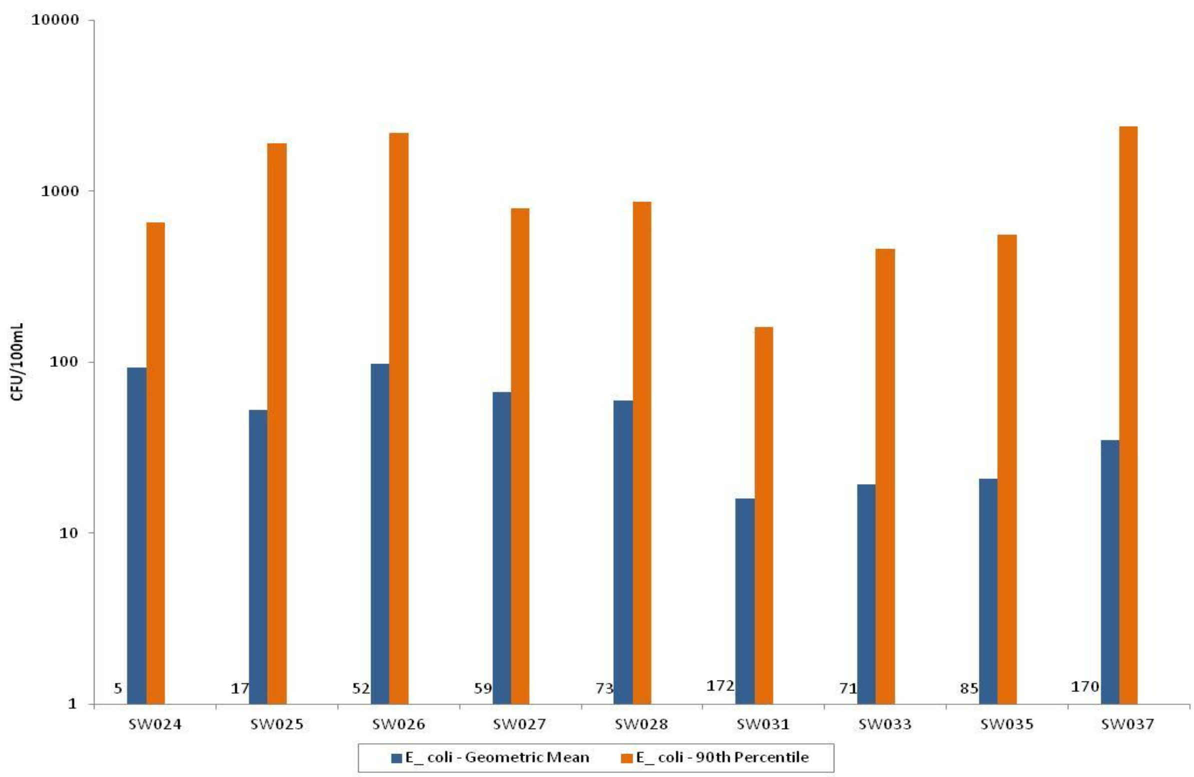

Figure 6.30 Class A Freshwater *E.coli* Results: Period of Record through 2011

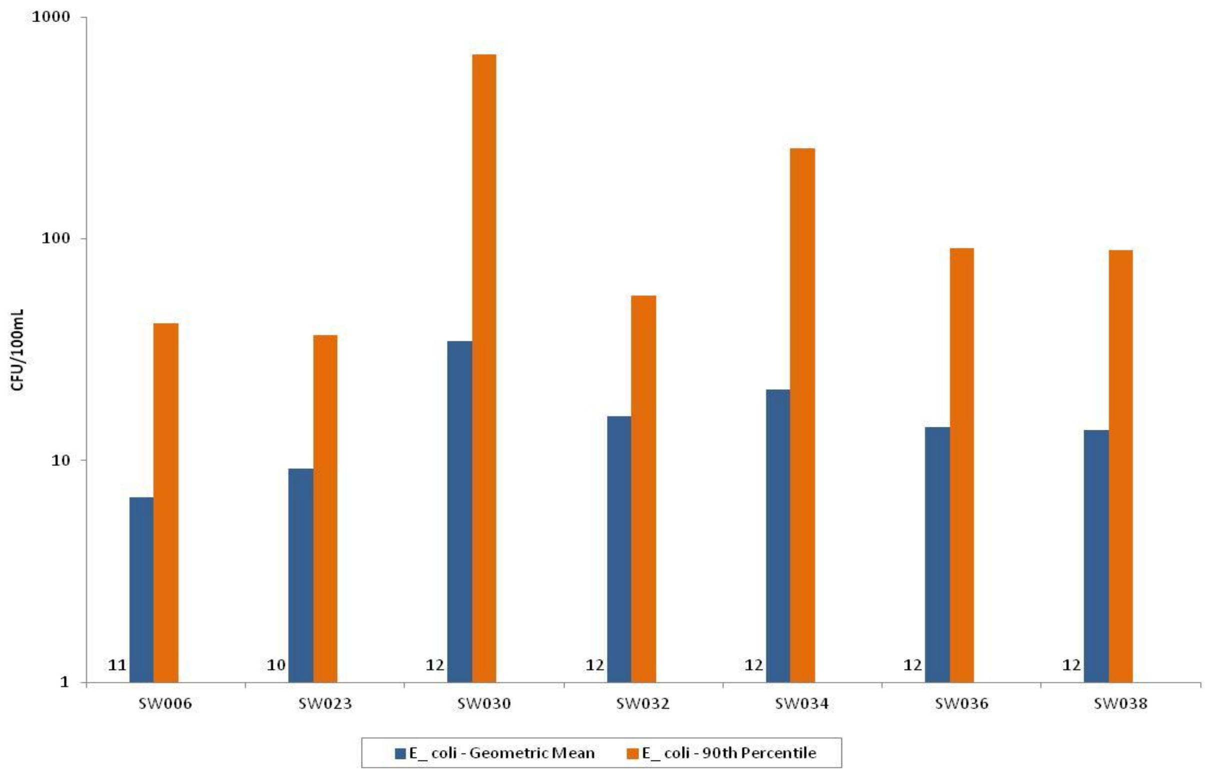

Figure 6.31 Class A Marine Water *E.coli* Bacteria Results: 2012

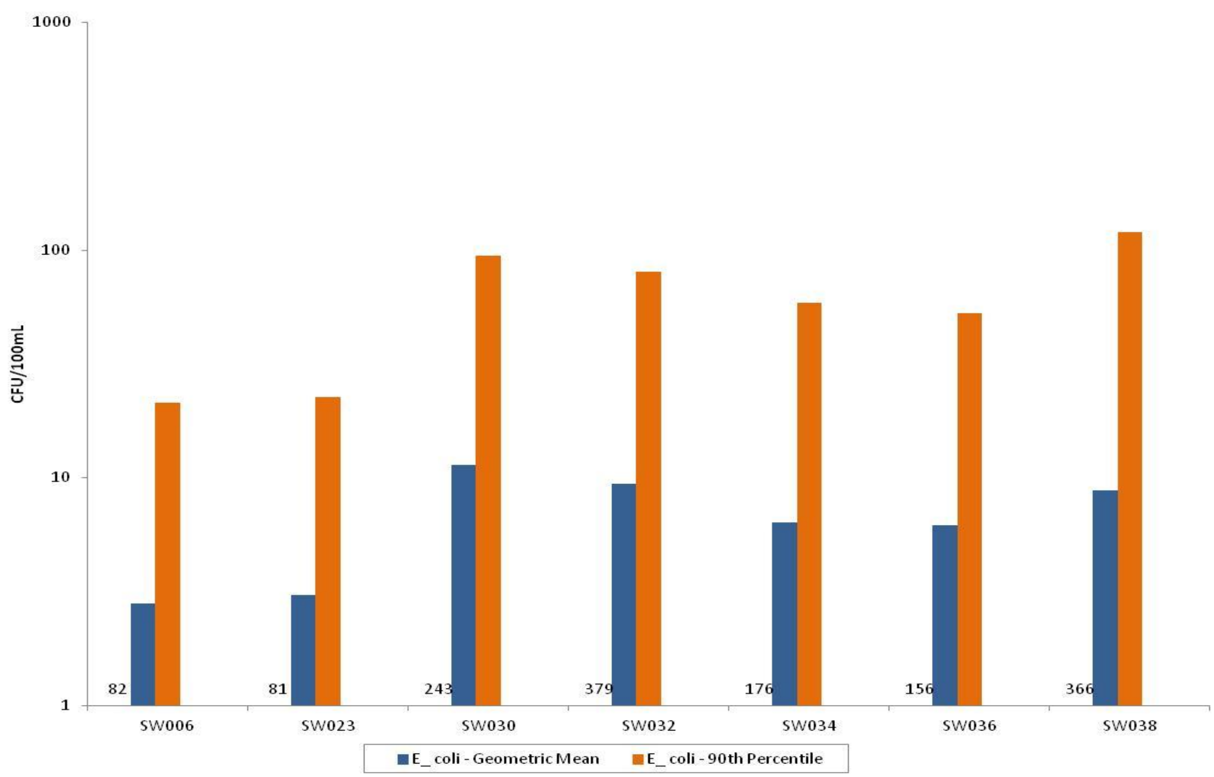

Figure 6.32 Class A Marine Water *E.coli* Bacteria Results: Period of Record through 2011

6.6. Water Temperature Results

Similar to bacteria, the standards for water temperature are set at a maximum value. If the maximum measured water temperature is greater than the water quality criteria, the sample results indicate that the characteristic uses of the water body are not fully supported. The existing sampling program collects single measurements of water temperature at all sample sites during a sampling run that typically occurs once each month. Since the water quality standards are expressed as the 7-day average of the daily maximum value in the case of freshwater sites, and the 1-day maximum temperature for marine water sites, the collected data do not allow a direct comparison with the applicable water quality standards. However, the sample results provide an indicator of whether the water quality standards were exceeded at that time. Box-and-whisker plots were also generated to depict seasonal variations and trends over the period of record from a representative sample site from the same water body classification. The top and bottom of the box represent the bounds of the first and third quartiles, while the red triangle inside the box represents the second quartile or median. The whiskers extending from the box indicate variability outside the upper and lower quartiles. Any data not included between the whiskers are plotted as an outlier with a small green dot.

Continuous recording water temperature probes were deployed at ten of the surface water monitoring sites during 2012. The data collected at the ten sites with continuous temperature dataloggers will allow direct comparison with the applicable water quality standards at these sites. Due to lost or damaged equipment, seven of the ten sites have a complete continuous water temperature data set, two sites have eight months of data, and one site has no data during 2012.

6.6.1. Class AA Waters

The Class AA freshwater quality standard for water temperature is a 7-day average of the daily maximum value (7DADM) temperature of 16.0°C. For summer time spawning, temperature shall not exceed a 7DADM temperature of 13.0°C. As shown in Figure 6.33, the water quality data collected during 2012 indicate that this standard was exceeded at 9 of the 15 sample sites. As shown in Figure 6.35 of the 9 sites that did not achieve the water quality standard during 2012, 6 sites achieved the standard at least 75% of the time sampled, and 3 sites achieved the standard less than 75% of the time sampled during 2012. Although sample Site SW004 is shown in Figure 6.33 to have met this standard during 2012, this result reflects the laboratory findings from only one sample. As described previously, SW004 is only sampled during flood conditions in the Nooksack River where sampling at Site SW118 would be dangerous. As shown in Figure 6.33 and Figure 6.34, the water temperature was always below the standard at two of the Class AA freshwater monitoring sites (SW029 and SW004). Site SW029 is in a largely forested watershed that drains a portion of the Lummi Peninsula.

The Class AA marine standard for water temperature is a 1-day maximum temperature of 13.0°C. As shown in Figure 6.36, the water temperature standard was achieved at Class AA marine water quality monitoring Sites DH039, DH040, and DH287 during 2012. However, as shown in Figure 6.37 the standard was exceeded at least once at all of the sites sampled during the period of record through 2011. As shown in Figure 6.35, 8 of the 24 Class AA marine water sites achieved the standard at least 75% of the time sampled during 2012, while the remaining 13 sample sites achieved the standard less than 75% of the time sampled during 2012.

As shown in Figure 6.38, the water temperature sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009 on the Lummi River along the northern Reservation boundary) have generally been below the 16.0°C threshold over the period of record. In contrast, as shown in Figure 6.39, the water temperature sample results for the representative Class AA marine water site (SW002 in Lummi Bay) have commonly been above the 13.0°C threshold over the period of record. Site SW002 is located on the tide flats of Lummi Bay and the water temperature increases as the tidal waters flow over the mud flats. There is likely not an anthropogenic cause for the elevated temperatures at this location.

As shown by the box-and-whisker plot in Figure 6.40, the water temperature at Site SW009 varies during the year with the highest temperatures occurring during July and August and the lowest temperatures during December, January, and February. As shown in Figure 6.41, a similar pattern occurs at Site SW002 with the lowest temperatures occurring during December, January, and February.

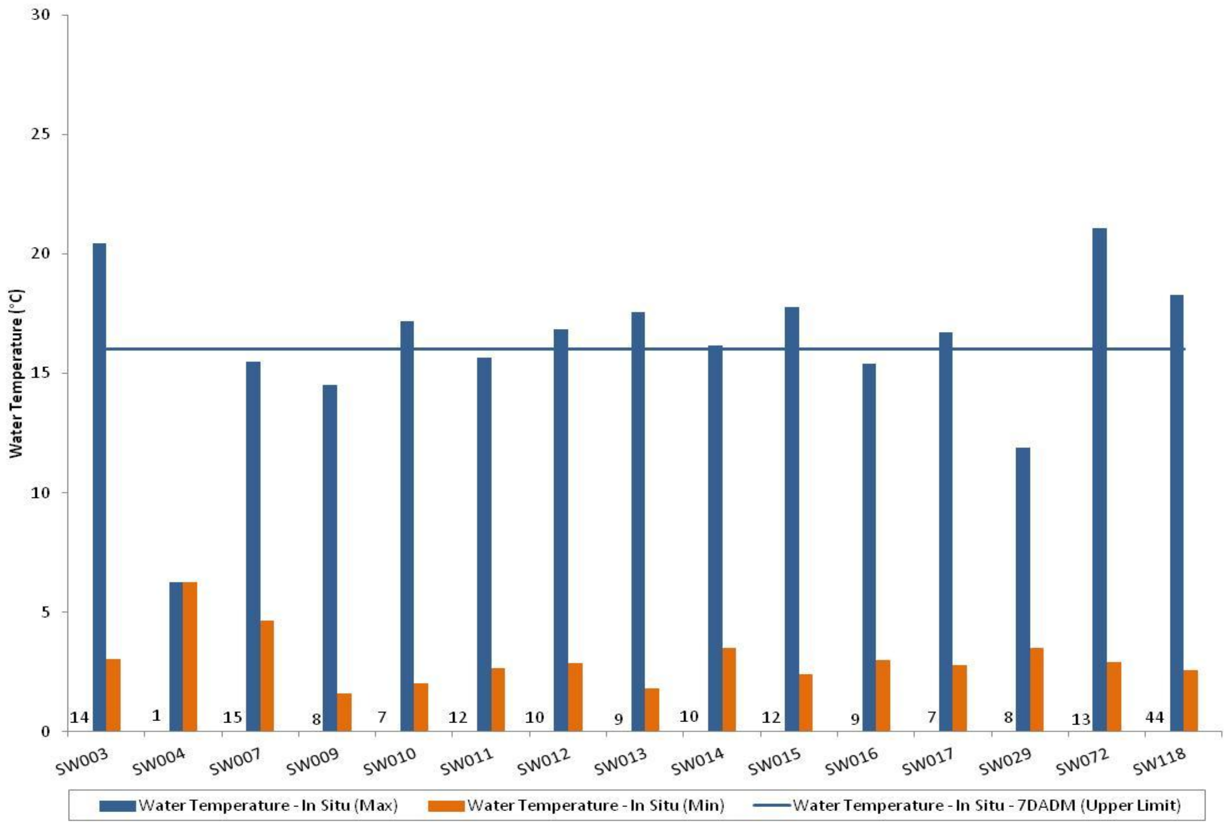

Figure 6.33 Class AA Freshwater Temperature Results Compared with Water Quality Standards: 2012

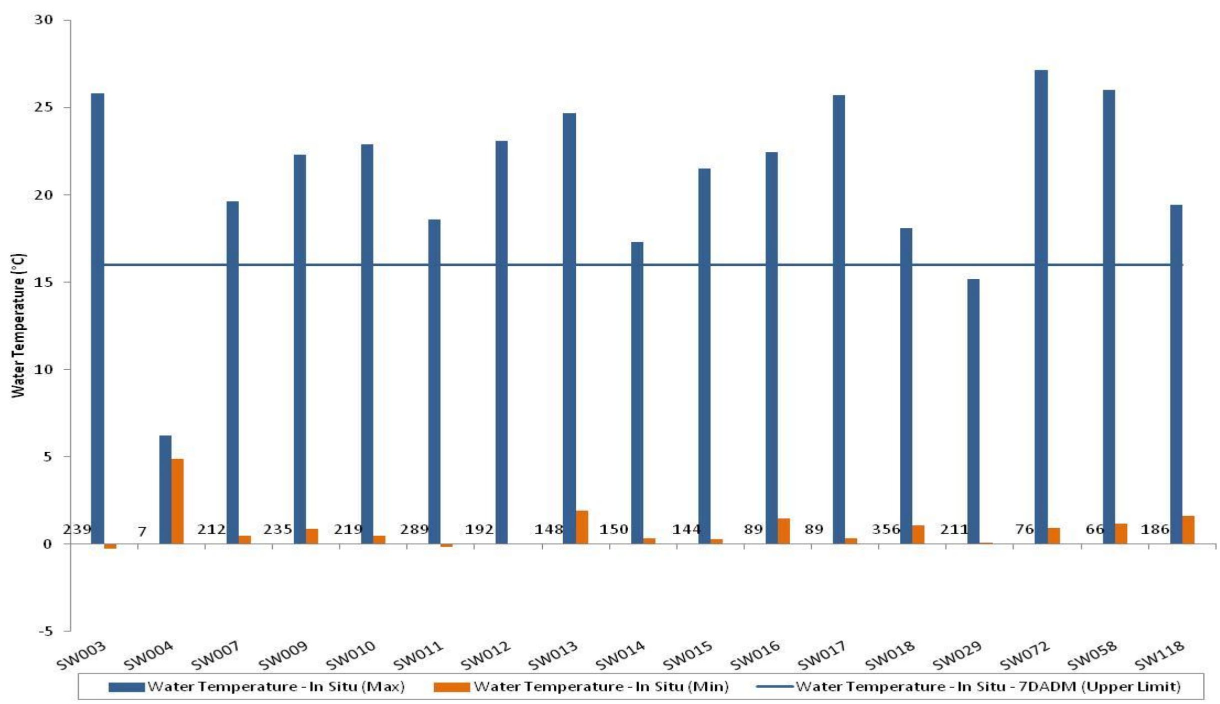

Figure 6.34 Class AA Freshwater Temperature Results Compared with Water Quality Standards: Period of Record through 2011

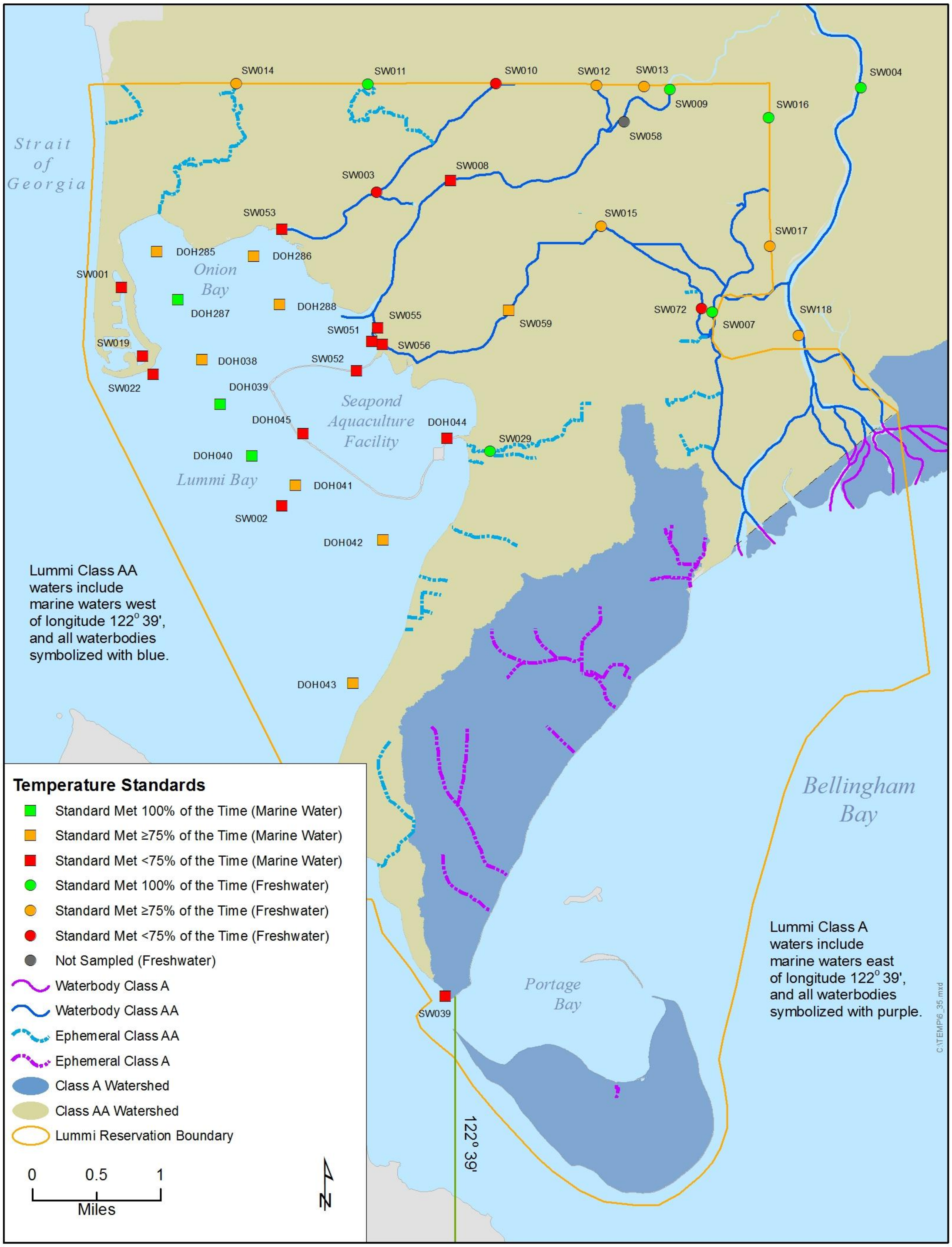

Figure 6.35 Class AA Freshwater and Marine Water Temperature Compliance with Water Quality Standards: 2012

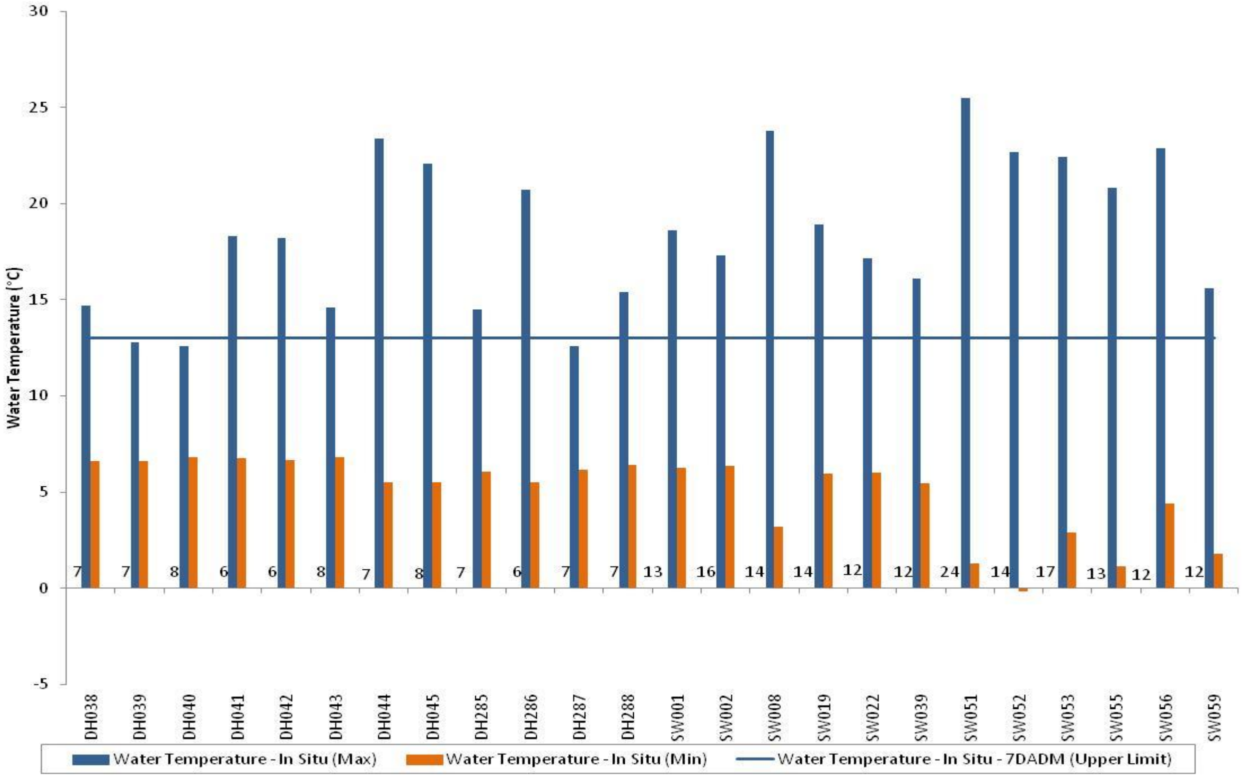

Figure 6.36 Class AA Marine Water Temperature Results Compared with Water Quality Standards: 2012

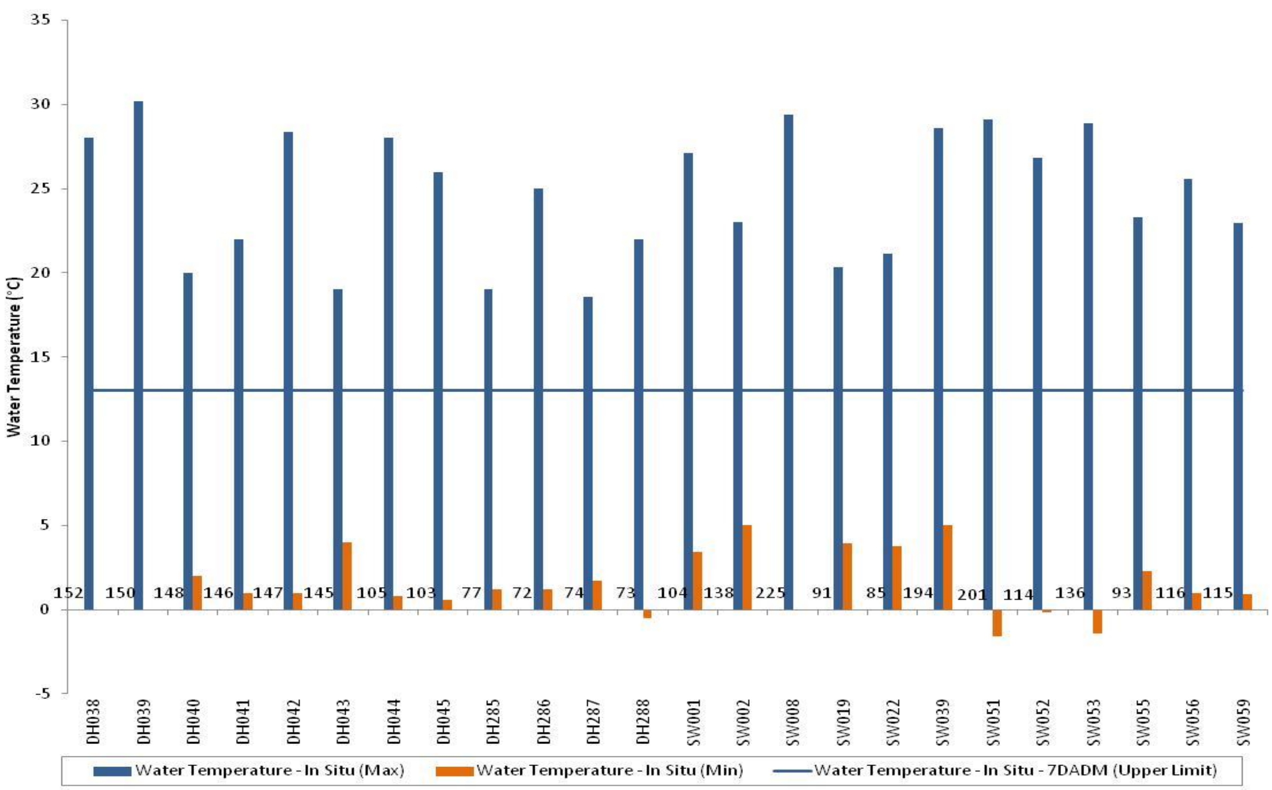

Figure 6.37 Class AA Marine Water Temperature Results Compared with Water Quality Standards: Period of Record through 2011

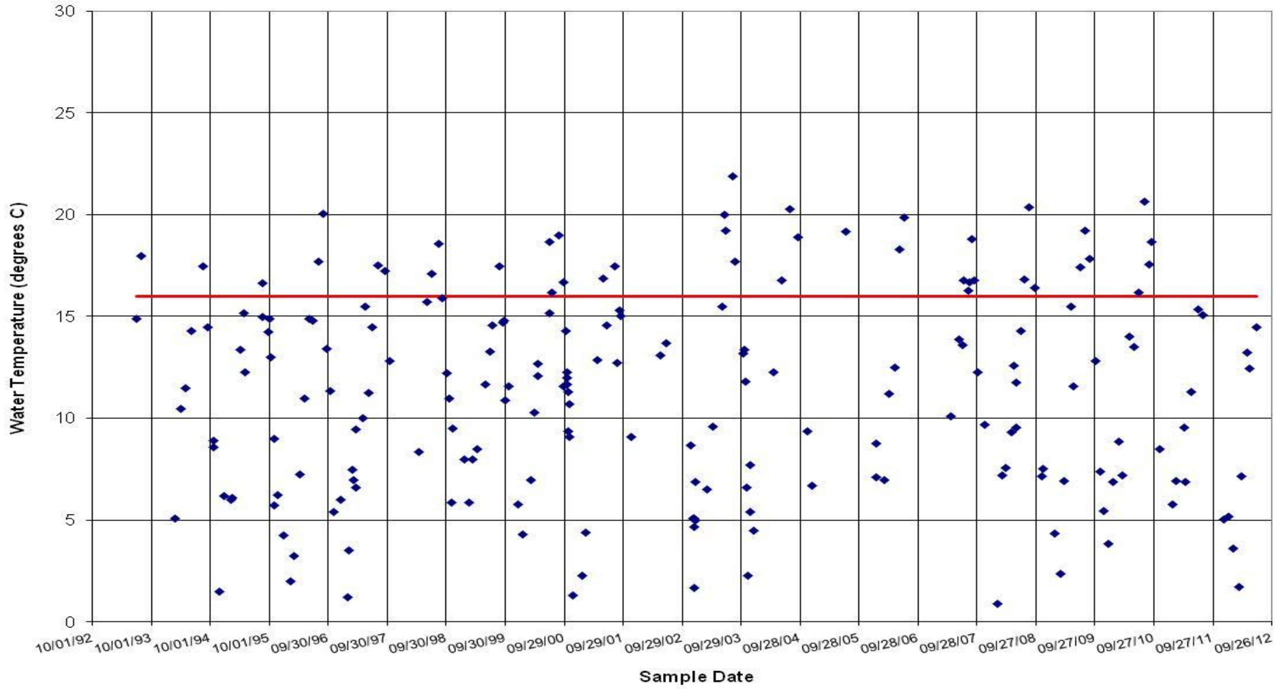

Figure 6.38 Class AA Freshwater Temperature Results, Site SW009

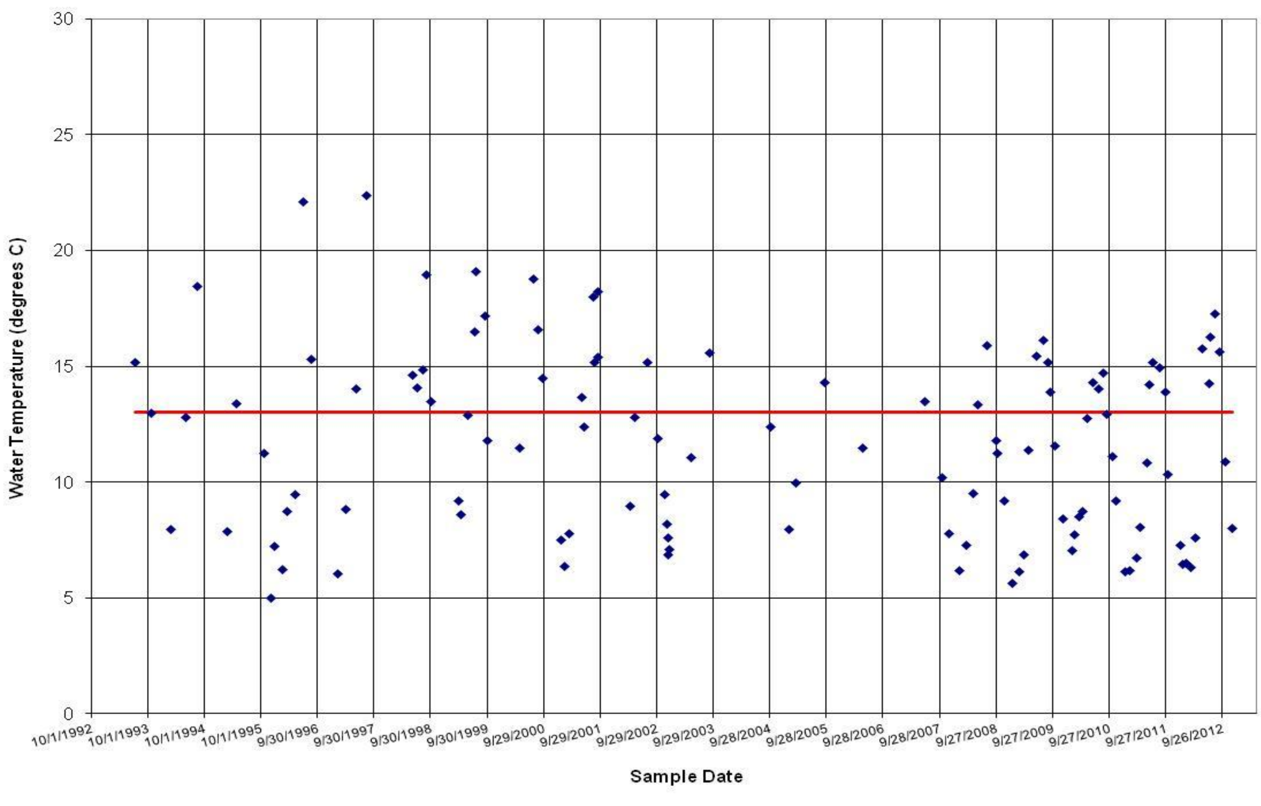

Figure 6.39 Class AA Marine Water Temperature Results, Site SW002

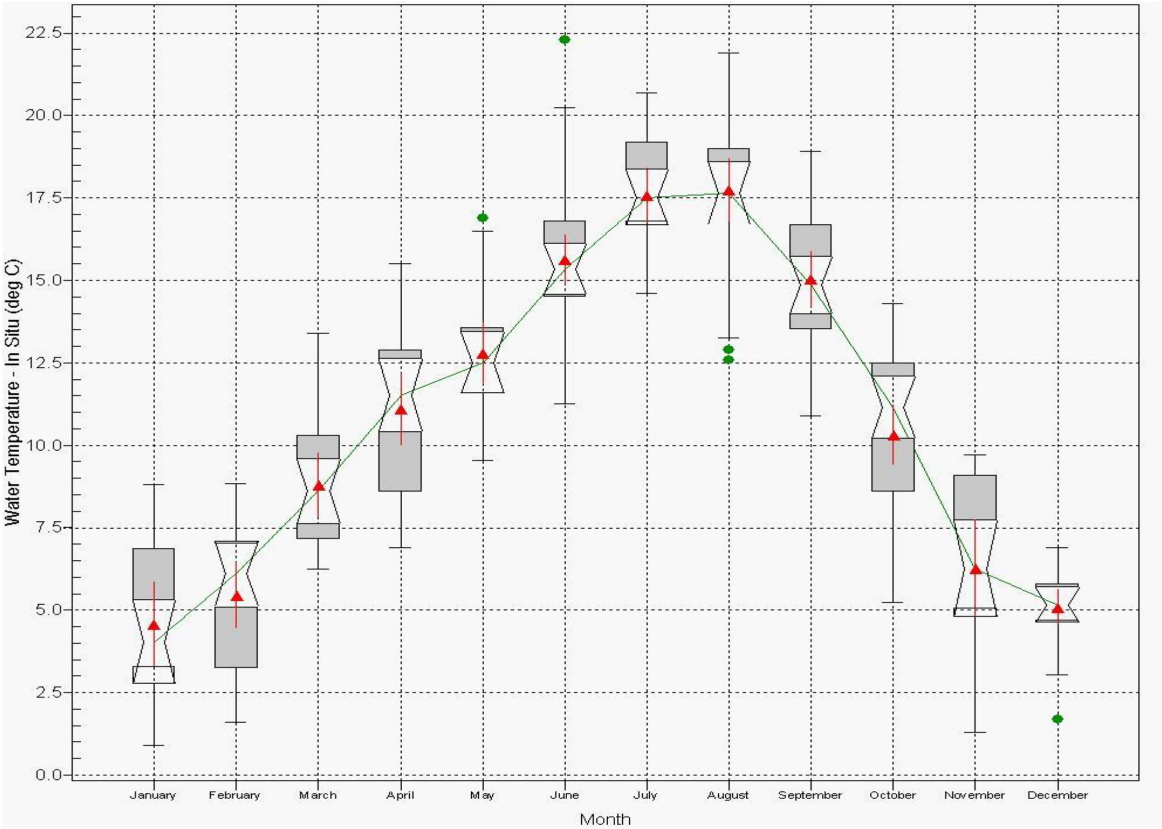

Figure 6.40 Monthly Temperature Variation for Period of Record, Site SW009

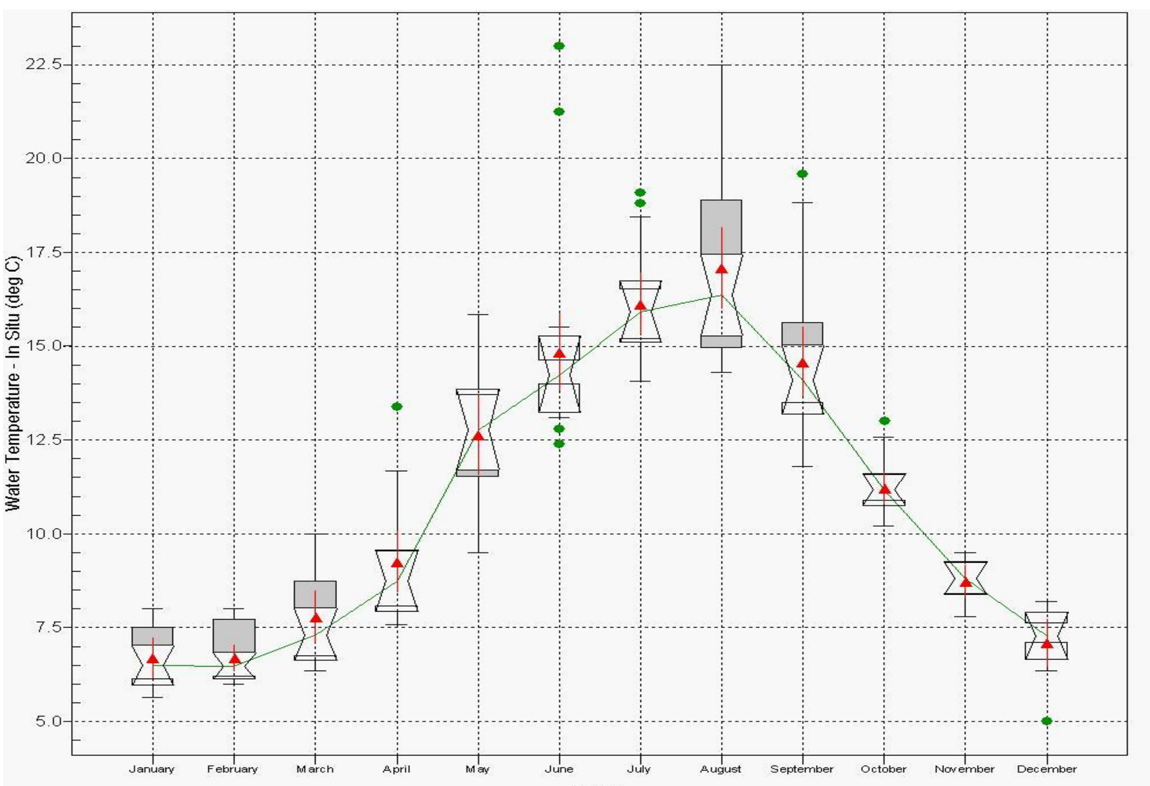

Figure 6.41 Monthly Temperature Variation for Period of Record, Site SW002

6.6.2. Class A Waters

The Class A freshwater standard for water temperature is a 7-day average of the daily maximum value (7DADM) of 17.5°C. As shown in Figure 6.42, the water quality data collected during 2012 suggest that this standard was achieved at all but 2 of the 7 sample sites. As shown in Figure 6.44, the two sample sites that did not achieve the water quality standard 100% of the time sampled during 2012 achieved the standard at least 75% of the time sampled. As shown in Figure 6.43, the water temperature was always below the standard at two of the Class A freshwater monitoring sites (SW024 and SW025). Both of these sites are in a largely forested watershed that drains a portion of Portage Island and are sites that are sampled infrequently due to limited flowing water.

The Class A marine water quality standard for water temperature is a 1-day maximum temperature of 16.0°C. As shown in Figure 6.45, the water quality collected during 2012 suggests that this standard was not achieved on at least one occasion at any of the 18 Class A marine water quality sample sites. As shown in Figure 6.44, 17 of the sites sampled during 2012 that did not achieve the water quality standard 100% of the time sampled achieved the standard at least 75% of the time sampled during 2012. As shown in Figure 6.46, the water temperature exceeded the standard at all of the 18 Class A marine water quality monitoring sites on at least one occasion over the period of record through 2011.

As shown in Figure 6.47, the water temperature sample results for the representative Class AA freshwater site that contributes to a Class A marine water site (SW018 and SW118 on the Nooksack River along the Reservation boundary) have generally been below the 16.0° C Class AA threshold over the period of record, with only one sample point above the standard during 2012. As shown in Figure 6.48, the water temperature sample results for the representative Class A marine water site (SW030 in Bellingham Bay) have also generally been below the 16.0°C Class A criterion over the period of record. Site SW030 is located on the tide flats of Bellingham Bay, which at this location are not as extensive as the tide flats of Lummi Bay near Site SW002. However, similar to Site SW002, the water temperature increases as the tidal waters flow over the mud flats and there does not appear to be an anthropogenic cause for the elevated water temperatures observed at this location.

As shown in Figure 6.49, the water temperature at Site SW118 varies during the year with the highest temperatures occurring during July, August, and September and the lowest temperatures during December through February. As shown in Figure 6.50, a similar pattern occurs at Site SW030.

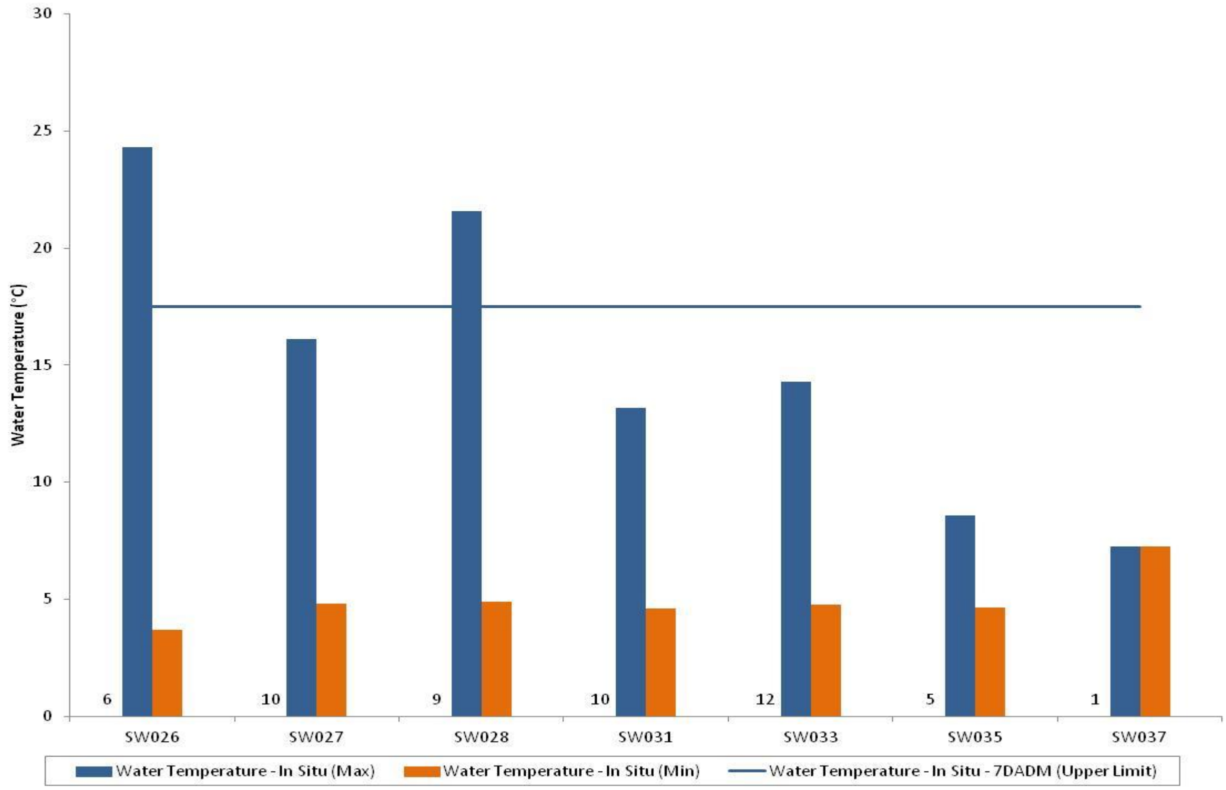

Figure 6.42 Class A Freshwater Temperature Results Compared with Water Quality Standards: 2012

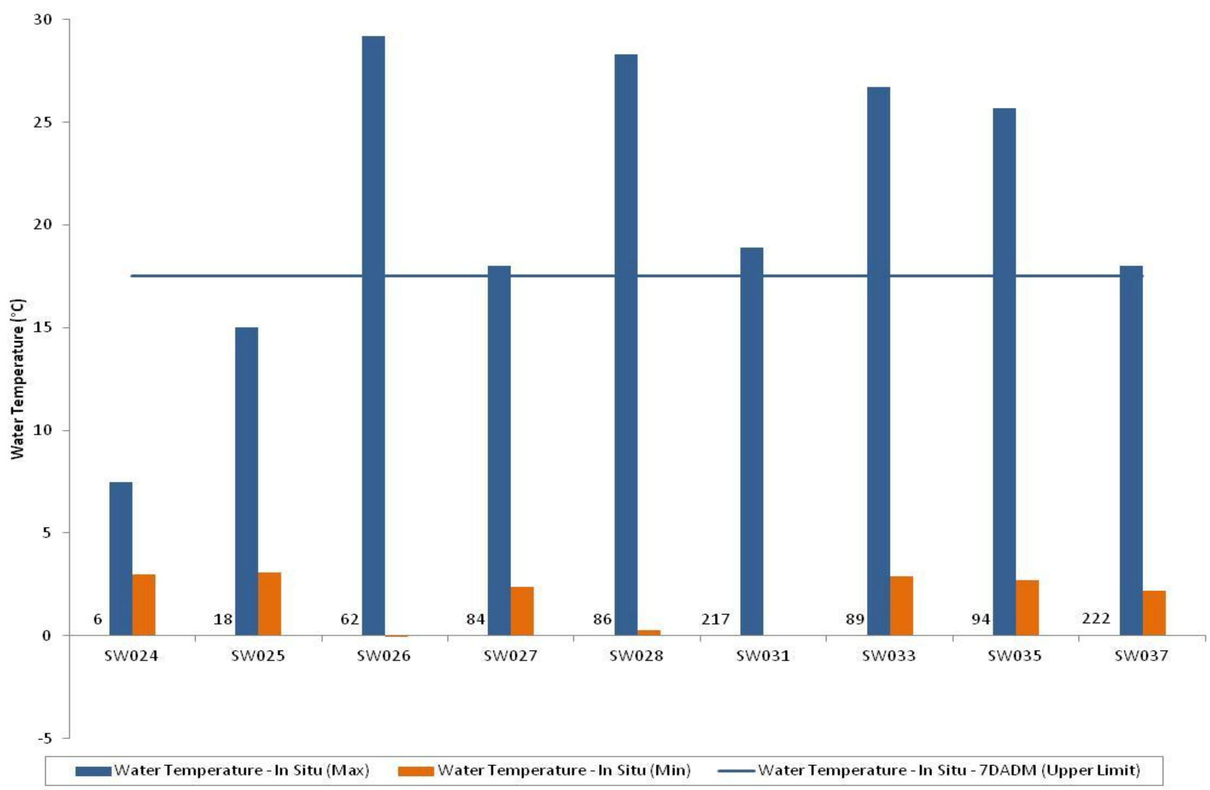

Figure 6.43 Class A Freshwater Temperature Results Compared with Water Quality Standards: Period of Record through 2011

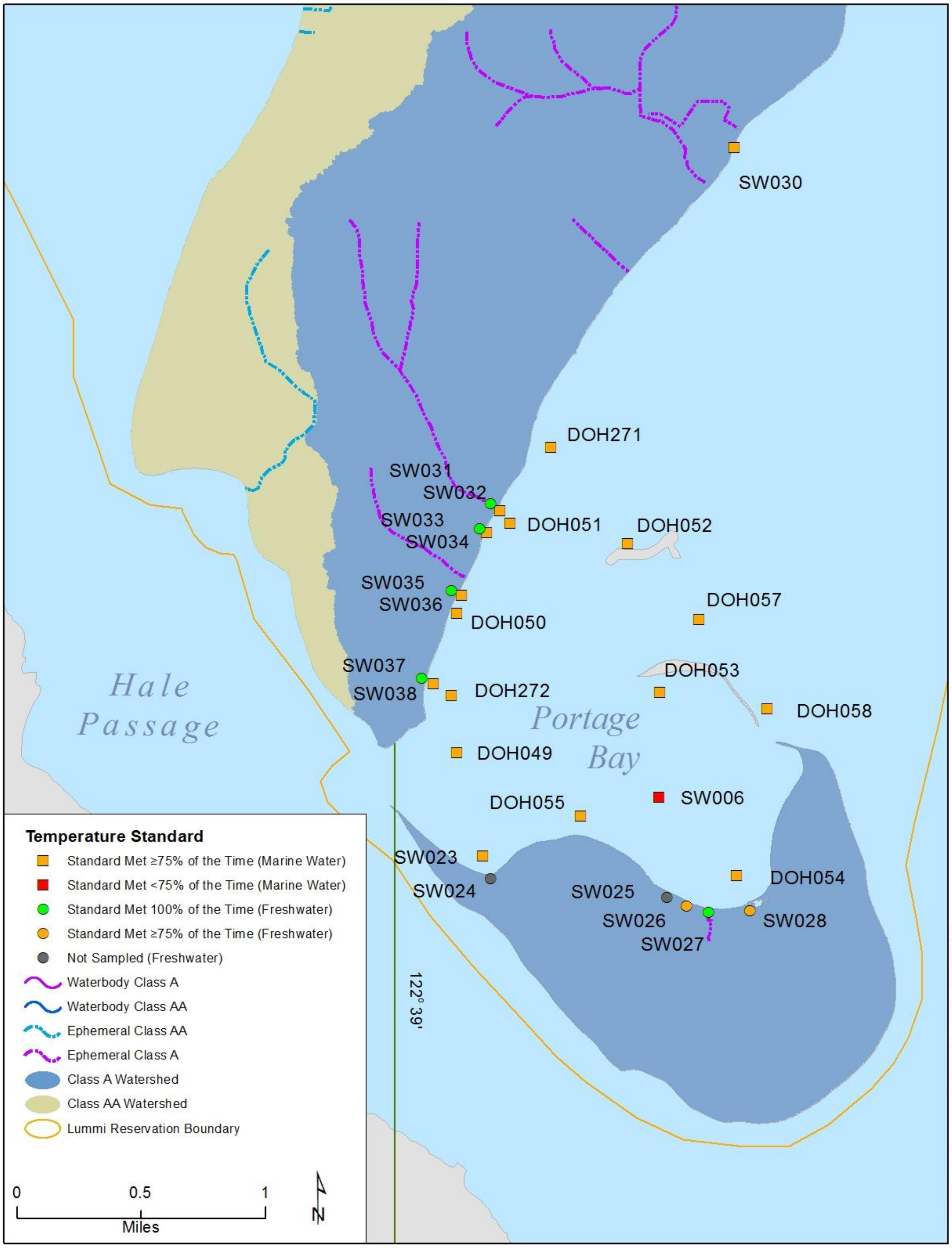

Figure 6.44 Class A Freshwater and Marine Water Temperature Compliance with Water Quality Standards: 2012

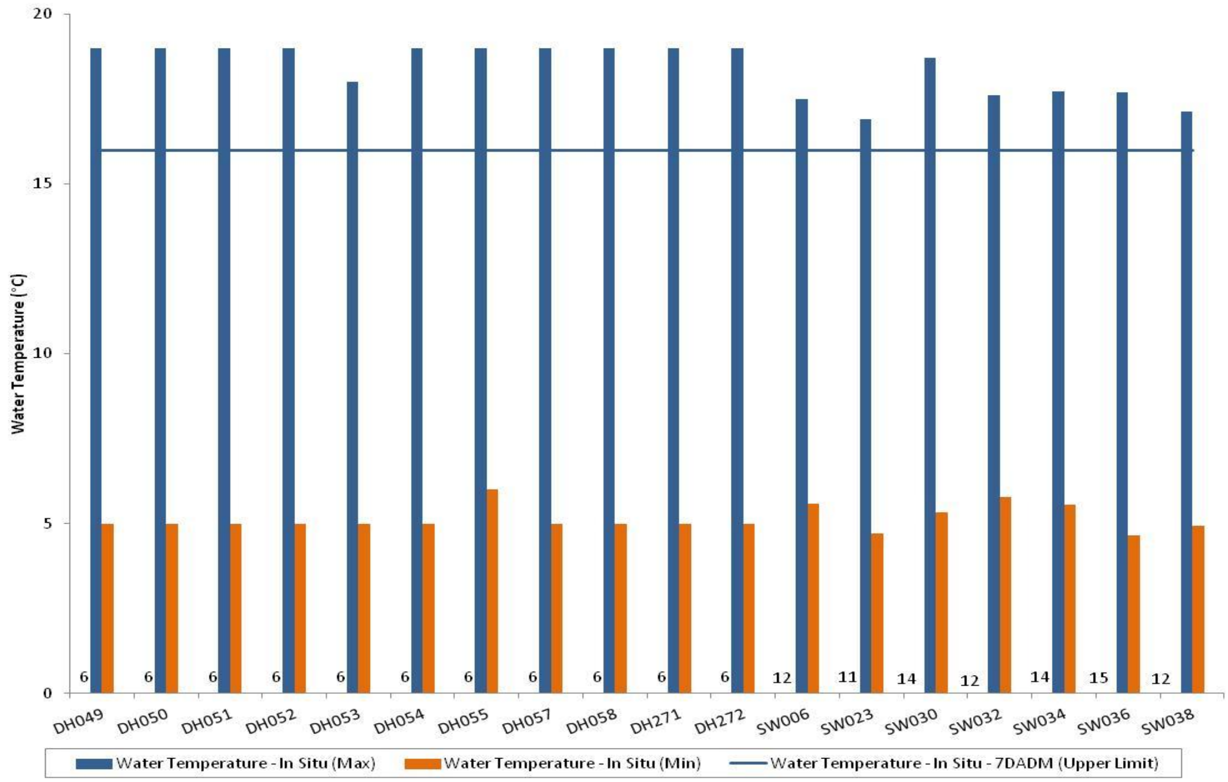

Figure 6.45 Class A Marine Water Temperature Results Compared with Water Quality Standards: 2012

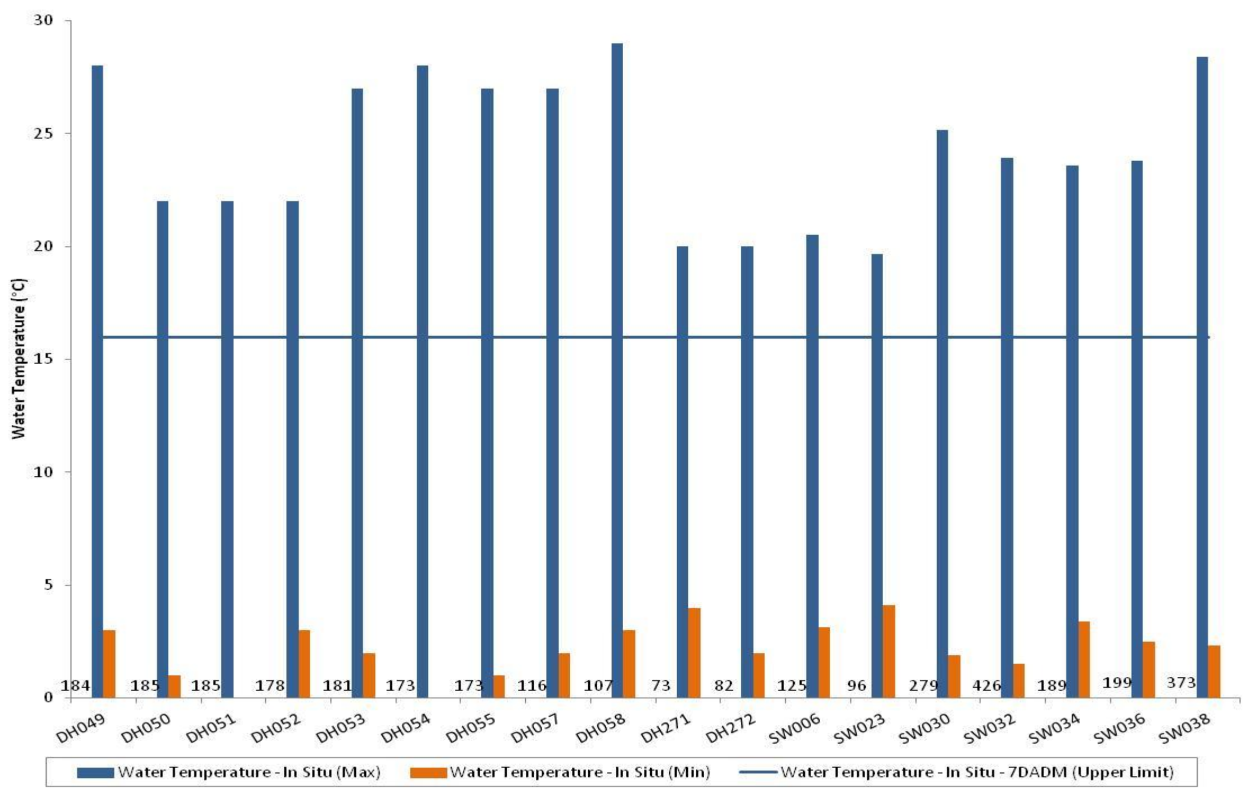

Figure 6.46 Class A Marine Water Temperature Results Compared with Water Quality Standards: Period of Record through 2011

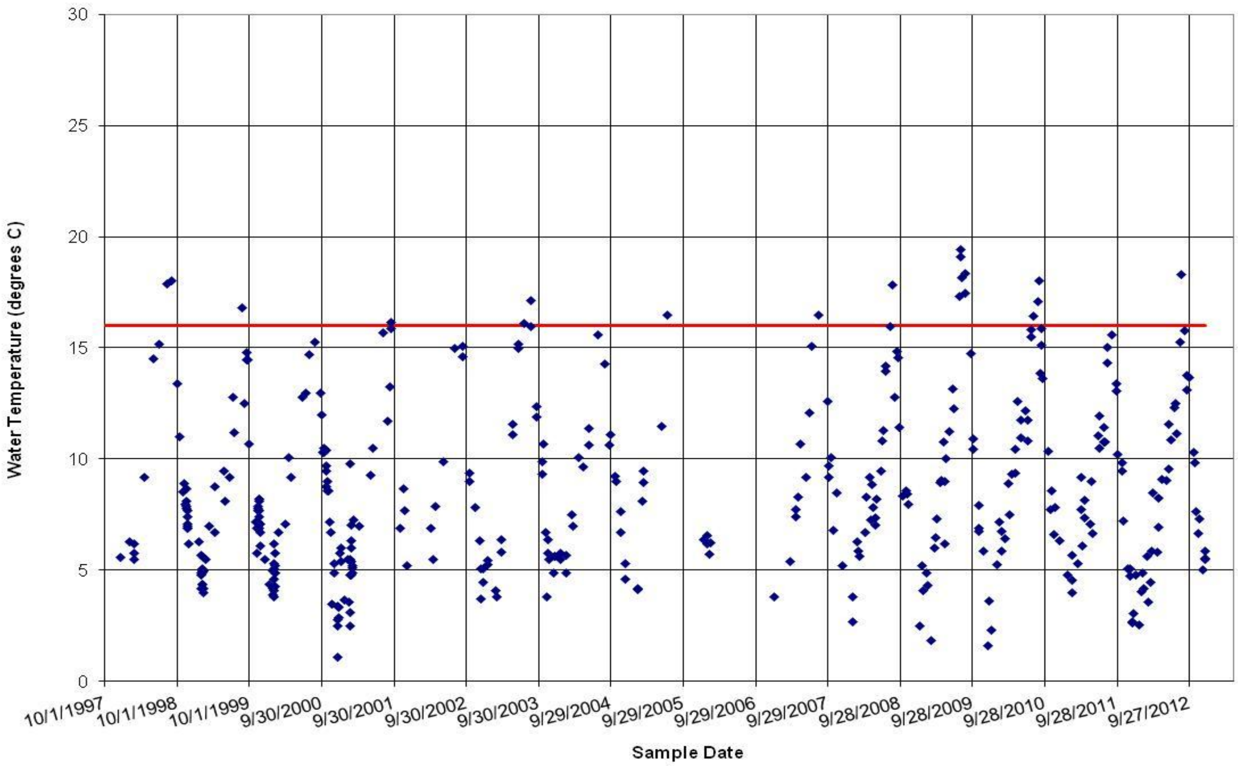

Figure 6.47 Class AA Freshwater Temperature Results, Site SW018/SW118

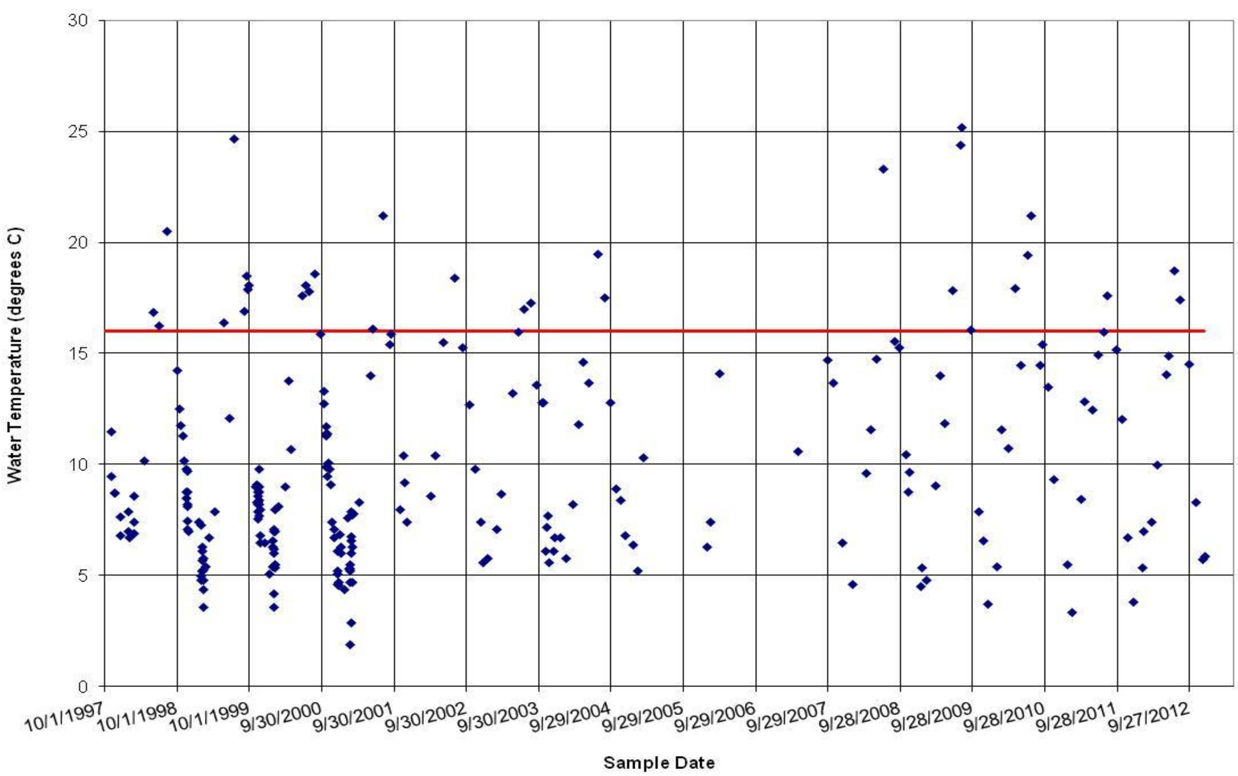

Figure 6.48 Class A Marine Water Temperature Results, Site SW030

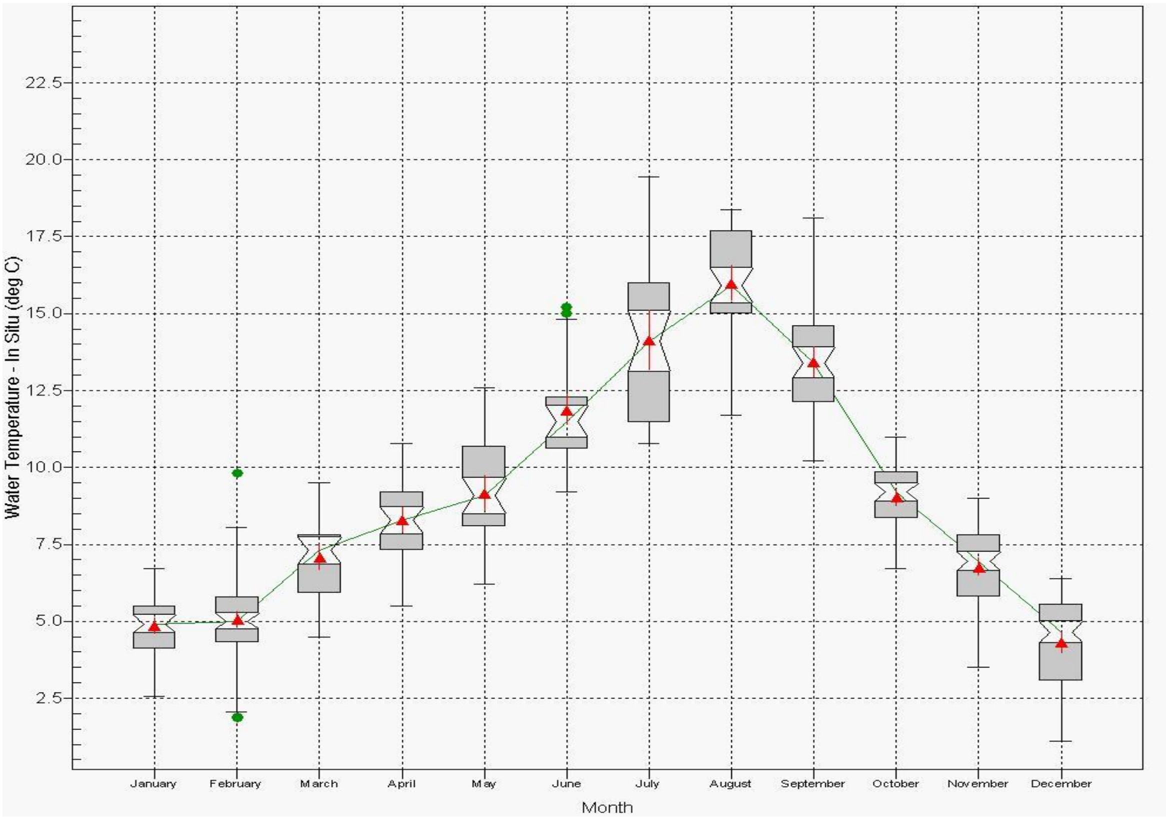

Figure 6.49 Monthly Temperature Variation for Period of Record, Site SW018/SW118

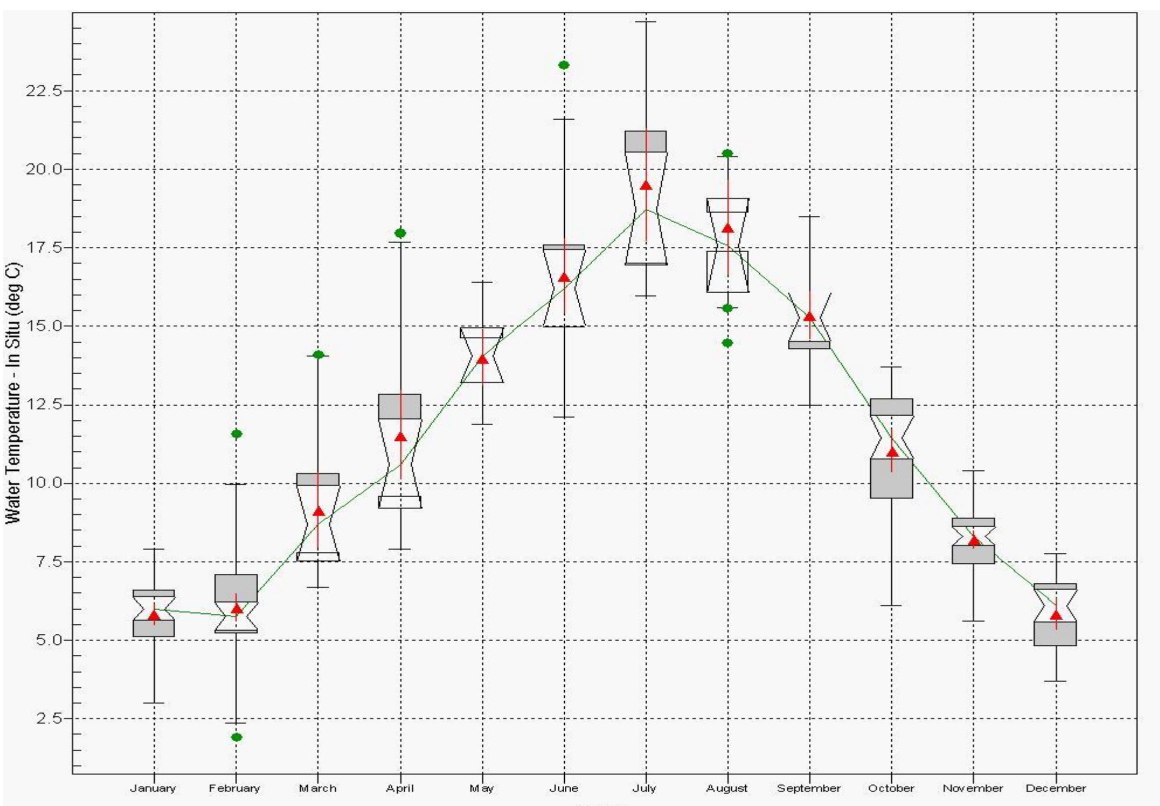

Figure 6.50 Monthly Temperature Variation for Period of Record, Site SW030

6.7.Continuous Temperature Results

The water quality standards for water temperature are established as a maximum value. If the maximum measured water temperature is greater than the water quality criteria, the characteristic uses of the water body are not fully supported. Prior to 2010, the sampling program only collected single measurements of water temperature at each site during a sampling run that typically occurs once each month. Because the water quality standards are expressed as the 7-day average of the daily maximum (7DADM) water temperature in the case of freshwater sites, and the 1-day maximum water temperature for marine water sites, continuous temperature monitoring is needed to accurately evaluate compliance with the water quality standards. Continuous recording water temperature probes were deployed at 10 of the monitoring sites during 2012. Temperature is measured continuously by each probe and the average temperature is recorded every 30 minutes at each site. The temperature data are downloaded from the dataloggers on a monthly basis. The data collected at the 10 sites with continuous temperature dataloggers allows direct comparison with the applicable water quality standards. Six freshwater Class AA sites and four marine water Class AA sites were chosen in the Jordan Creek, Lummi River, Smuggler’s Slough, and Nooksack River watersheds. Due to lost or damaged equipment of the water temperature dataloggers (Sites SW015, SW051, and SW118), seven of the ten sites have a complete data set for 2012.

6.7.1. Class AA Freshwater

The Class AA freshwater quality standard for water temperature is a 7-day average of the daily maximum value (7DADM) temperature of 16.0°C. For summer time spawning, temperature shall not exceed a 7DADM temperature of 13.0°C. Continuous water temperature data were collected at the following freshwater Class AA sites during 2012:

- SW003 – Jordan Creek at North Red River Road
- SW009 – Lummi River at Slater Road
- SW011 – Jordan Creek at Slater Road
- SW012 – Schell Creek at Slater Road
- SW015 – Smuggler’s Slough at Lummi Shore Road (8.75 months of data)

As shown in Figure 6.51 though Figure 6.55, the continuous water temperature data collected during 2012 indicate that the water quality criterion was exceeded at all five of the sites monitored. The water quality standard is generally exceeded at the sites from the beginning of June/July through the end of September, with the exception of Site SW003, where the standard was exceeded from May through the end of September. As shown in Figure 6.51 through Figure 6.55, the highest water temperatures occurred during July and August for all of the sites. The lowest temperatures occurred during January for all of the five sites. As shown in Figure 6.33, Site SW009 (Lummi River at Slater Road) and Site SW011 (Jordan’s Creek at Slater Road) did not exceed the water temperature standard during 2012 when sampled monthly. However, as shown in Figure 6.52, Site SW009 exceeded the 7DADM standard for over 14 weeks during 2012. As shown in Figure 6.53, Site SW011 exceeded the

7DADM standard for over two weeks during 2012. Site SW015 had the highest water temperatures of all the sites, with the 7DADM greater than 25^{o}C for over a week in July and again in August.

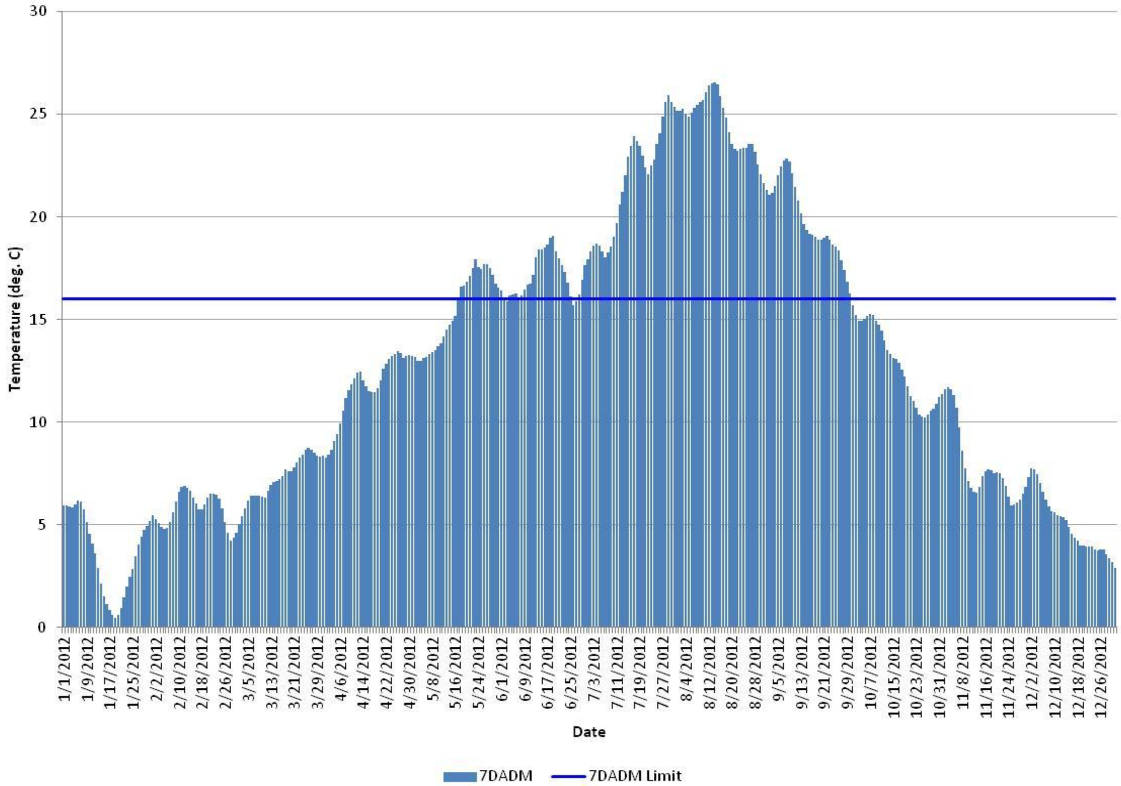

Figure 6.51 Maximum 7-Day Water Temperature Results, Site SW003

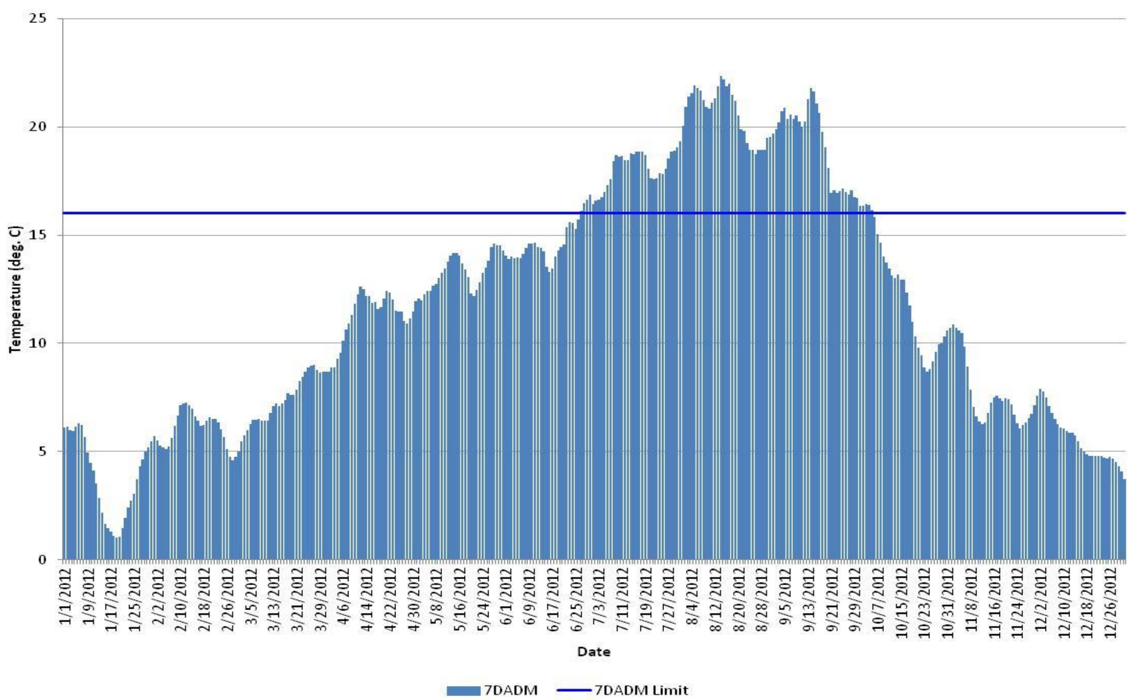

Figure 6.52 Maximum 7-Day Water Temperature Results, Site SW009

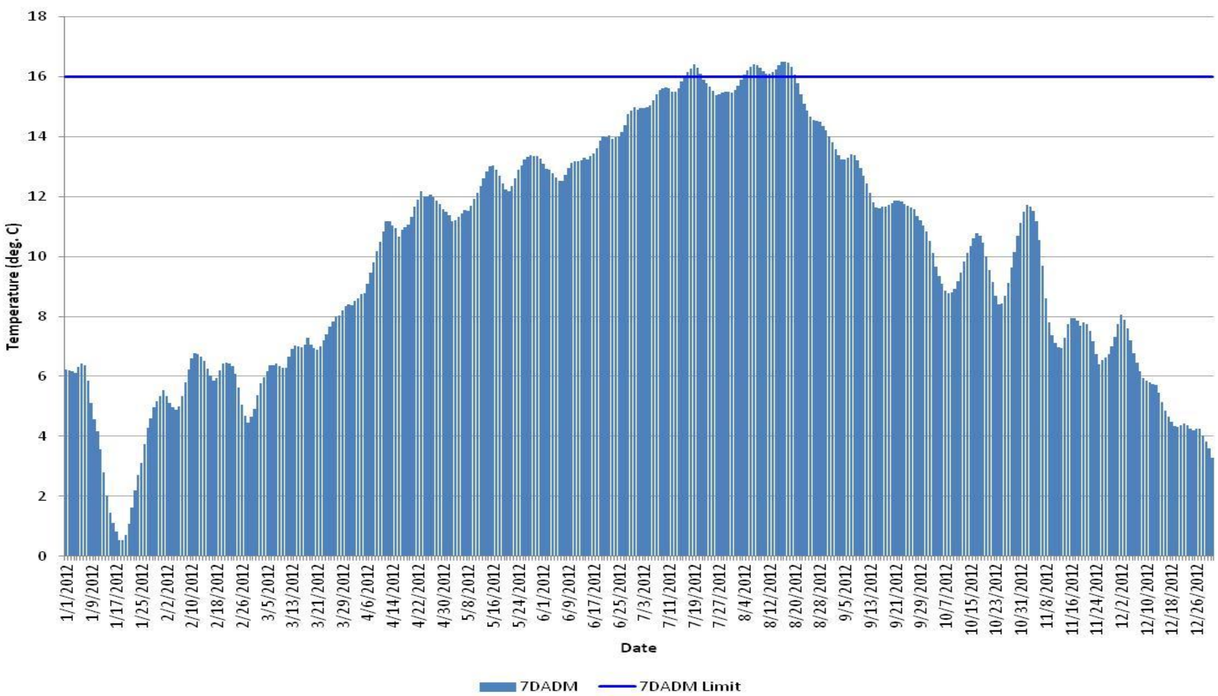

Figure 6.53 Maximum 7-Day Water Temperature Results, Site SW011

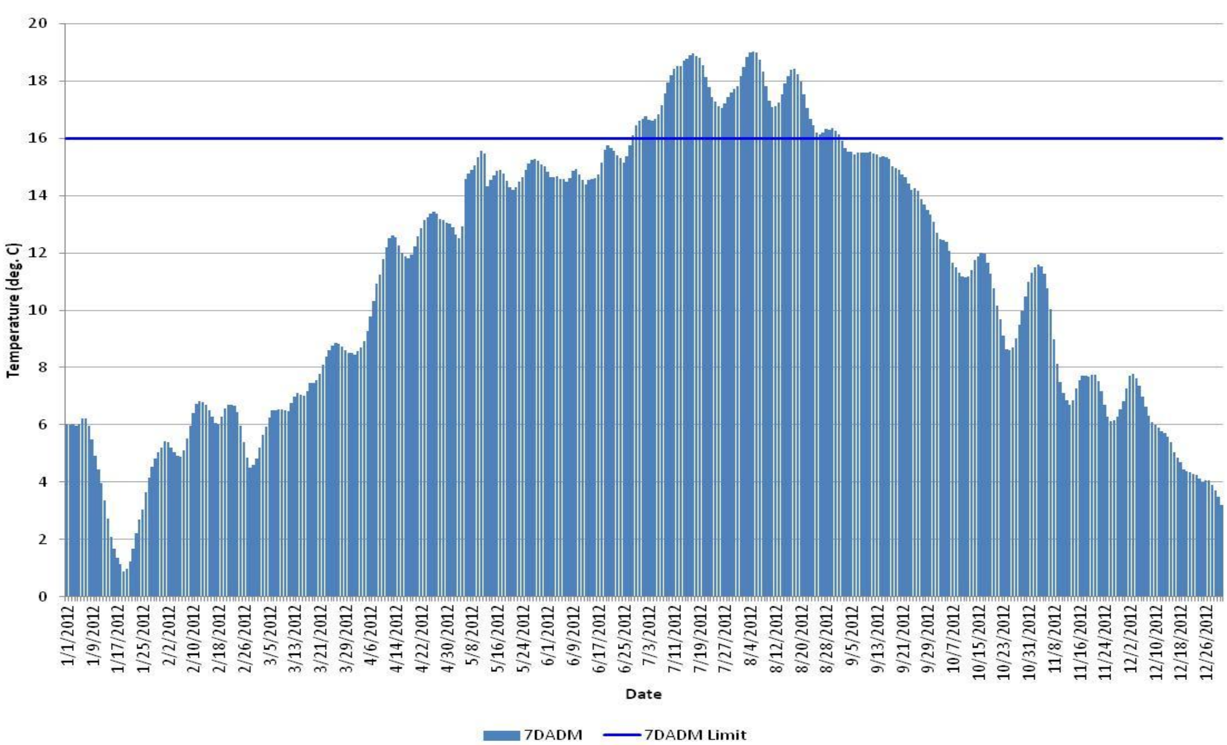

Figure 6.54 Maximum 7-Day Water Temperature Results, Site SW012

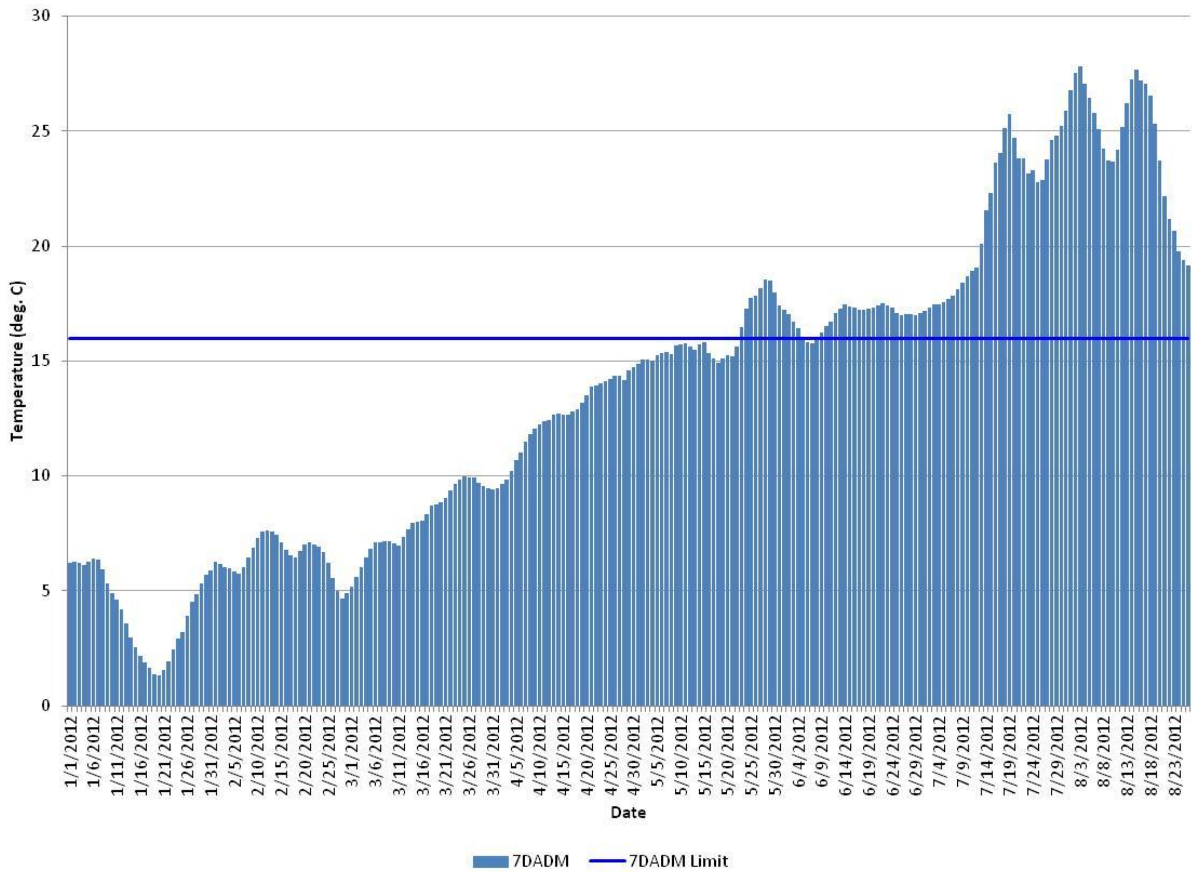

Figure 6.55 Maximum 7-Day Water Temperature Results, Site SW015

6.7.2. Class AA Marine Water

The Class AA marine water standard for water temperature is a 1-day maximum temperature of 13.0°C. Continuous water temperature data were collected at the following marine water Class AA sites during 2012:

- SW008 – Lummi River at Hillaire Road Bridge
- SW051 – Lummi River mouth (8 months of data)
- SW053 – Jordan Creek mouth
- SW059 – Smuggler's Slough at Kwina Road
- SW118 – Nooksack River at Marine Drive Bridge (no data)

As shown in Figure 6.56 through Figure 6.59, the water temperature exceeded the standard at all of the Class AA marine continuous water temperature monitoring sites during 2012. The water quality standard is generally exceeded at the Class AA marine water sites from the beginning of April/May through the beginning of September/October. As shown in Figure 6.56 through Figure 6.59, the highest temperatures occurred during June, July, and August and lowest temperatures occurred during January. Site SW059 (Smuggler's Slough at Kwina Road), which has the most tree cover of all the marine sites, always had water temperatures below 25^{o}C, whereas the other three sites consistently had water temperatures reaching above 25^{o}C during the warmest months. Site SW008 (Lummi River at Hillaire Road Bridge) and Site SW053 (Jordan Creek mouth), had a 1-Day maximum of over 30^{o}C in July 2012. The sites located furthest downstream (SW008, SW051, SW053, and SW059) in the watersheds have higher temperatures during the summer months than those sample sites located upstream.

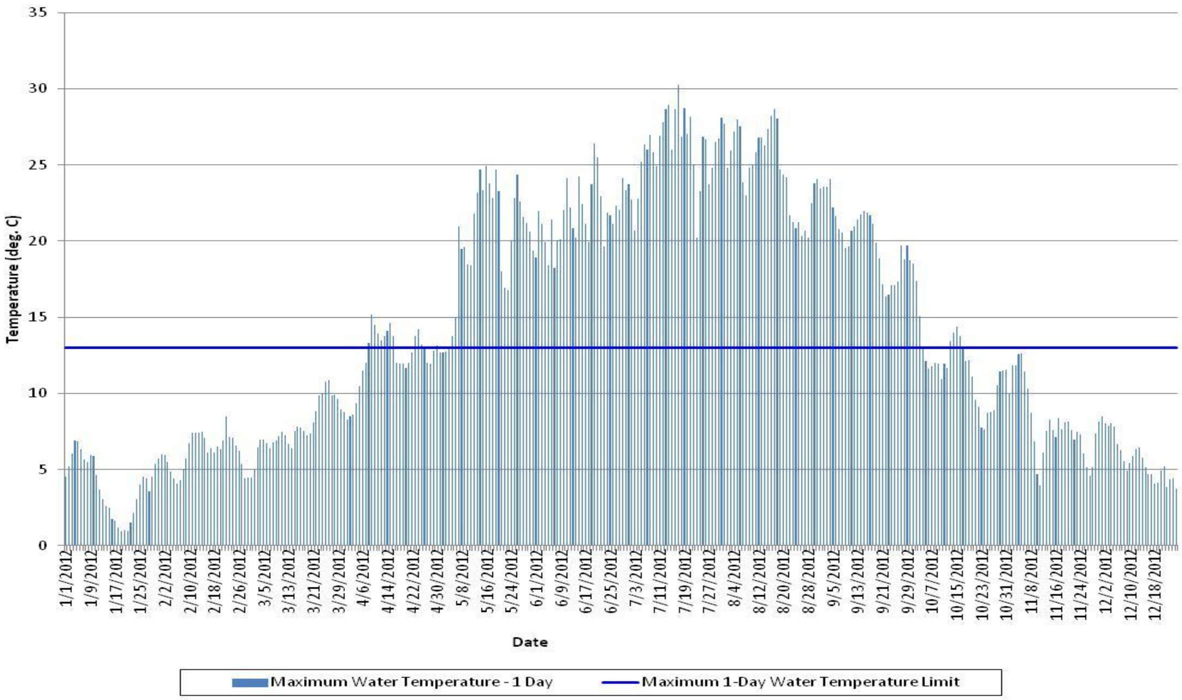

Figure 6.56 Maximum 1-Day Water Temperature Results, Site SW008

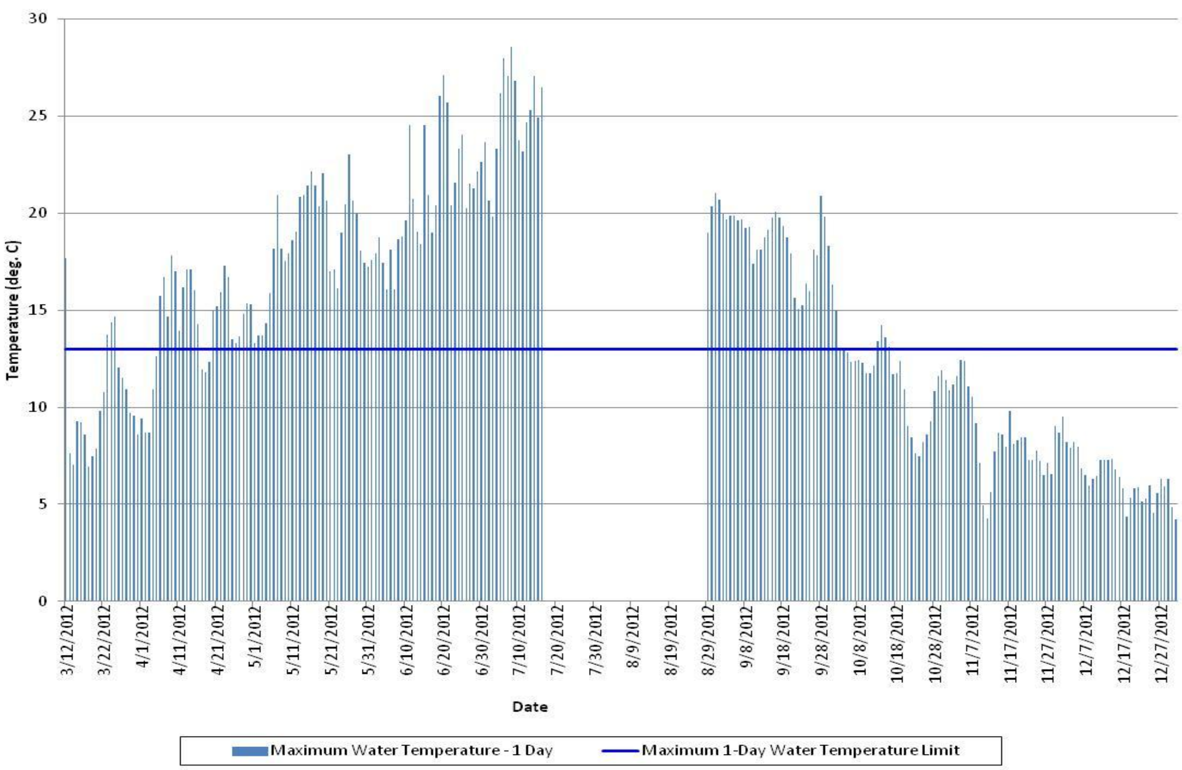

Figure 6.57 Maximum 1-Day Water Temperature Results, Site SW051

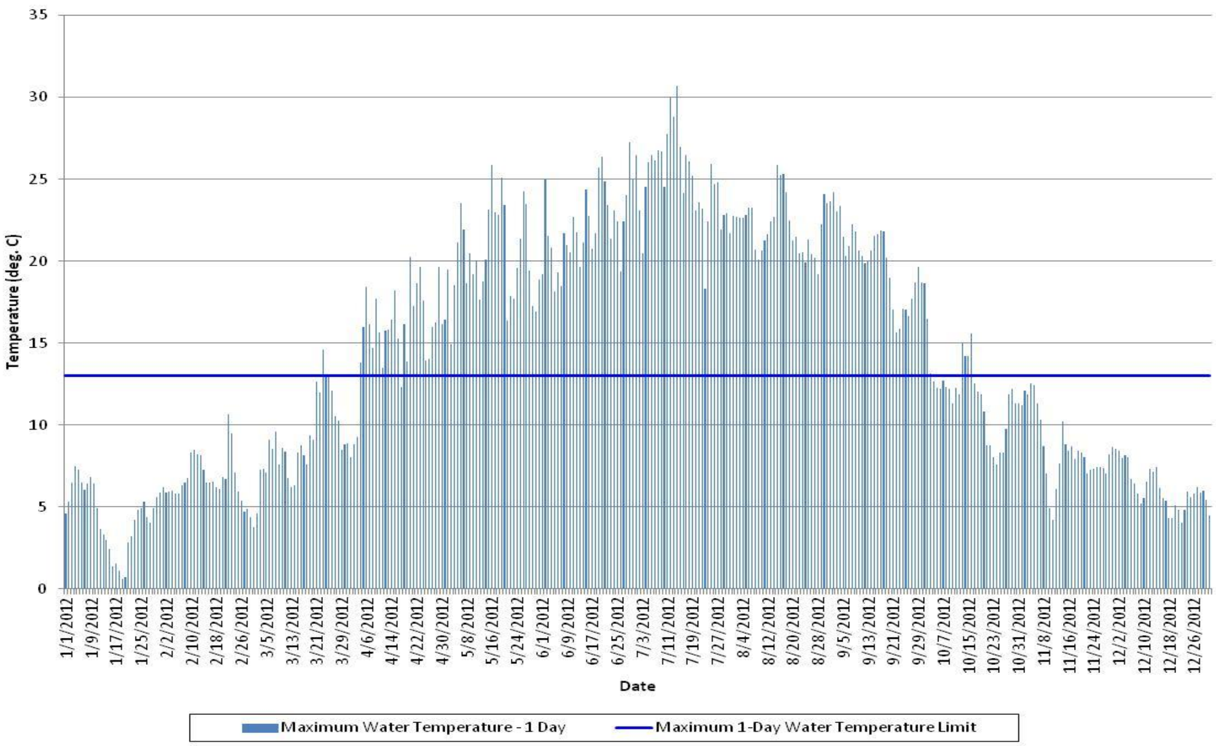

Figure 6.58 Maximum 1-Day Water Temperature Results, Site SW053

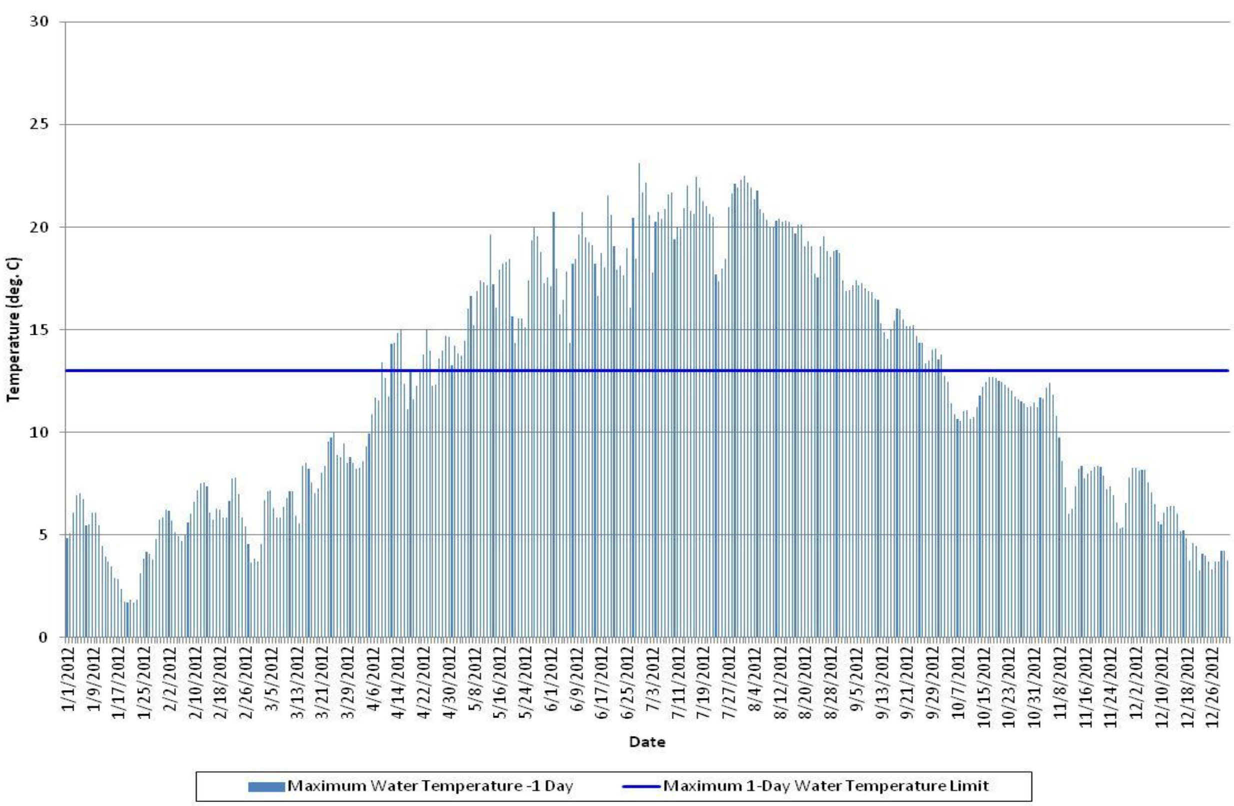

Figure 6.59 Maximum 1-Day Water Temperature Results, Site SW059

6.8.Dissolved Oxygen Results

In contrast to the bacteria and water temperature criteria, the water quality standards for dissolved oxygen are a minimum value. If the maximum or minimum measured dissolved oxygen levels are less than the water quality standard, the sample results indicate that the characteristic uses of the water body are not supported. The spatial median intergravel dissolved oxygen concentration is currently not measured at the sample sites so it is not possible to determine compliance with the water quality standards for Class AA freshwater sites.

6.8.1. Class AA Waters

The Class AA freshwater quality standard for dissolved oxygen is a minimum of 11.0 mg/l and a spatial median intergravel dissolved oxygen concentration greater than 8.0 mg/l. The spatial median intergravel dissolved oxygen concentration is currently not measured at the sample sites so it is not possible to determine compliance with the water quality standards for Class AA freshwater sites. As shown in Figure 6.60, the water quality data collected during 2012 indicate that the 11.0 mg/l part of the standard was achieved at least once for 11 of the 15 sample sites and was not achieved at the 4 remaining sites. However, as discussed previously if the maximum or minimum measured dissolved oxygen levels are less than the water quality standard, the characteristic uses of the water body are not supported and the water quality standard is not achieved. As shown in Figure 6.62, although 11 of the 15 sample sites achieved the water quality standard on at least one occasion during 2012, none of the regularly sampled sites achieved the standard 100% of the time sampled. Site SW004 is shown to have achieved the water quality standard; however, SW004 is only sampled during flooding along the Nooksack River, when regular sample Site SW118 cannot be safely accessed, and was only sampled once during 2012. Only two sites achieved the standard at least 75% of the time sampled, and the remaining 12 sites achieved the standard less than 75% of the time sampled during 2012. As shown in Figure 6.61, the dissolved oxygen levels have been above the 11.0 mg/l criterion at least once at every site except for Site SW072, where dissolved oxygen has never been measured above the 11.0 mg/l criterion. Site SW004 is the only site to meet the minimum dissolved oxygen level requirement over the period of record. All other Class AA freshwater sites have had measured minimum dissolved oxygen levels below the water quality standard on at least one occasion.

The Class AA marine water quality standard for dissolved oxygen is a 1-day minimum daily concentration of 7.0 mg/l. As shown in Figure 6.63, the water quality data collected during 2012 suggest that this standard was achieved at least once at all 24 of the sample sites, and 16 of the 24 sample sites were consistently above the standard during 2012. As shown in Figure 6.62, of the 8 sample sites that were not consistently above the water quality standard during 2012, 4 of the sites achieved the water quality standard at least 75% of the time sampled. As shown in Figure 6.64, the dissolved oxygen standard was consistently achieved over the period of record at Site DH038 (Lummi Bay) and Site SW039 (along Hale Passage) of the Class AA marine water monitoring sites.

As shown in Figure 6.65, the dissolved oxygen sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009) have generally been below the minimum 11.0 mg/l criterion over the period of record. In contrast, as shown in Figure 6.66, the dissolved oxygen sample results for the representative Class AA marine water site (SW002) have generally been above the 7.0 mg/l criterion over the period of record.

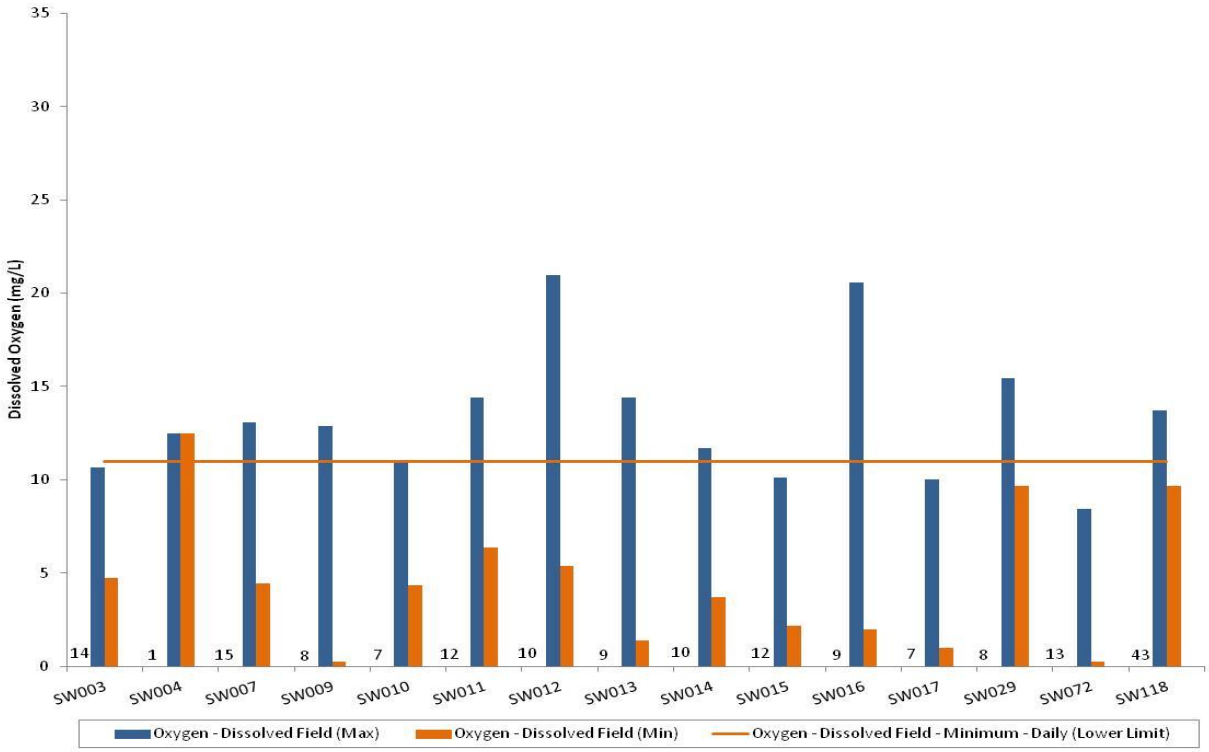

Figure 6.60 Class AA Freshwater Dissolved Oxygen Results Compared with Water Quality Standards: 2012

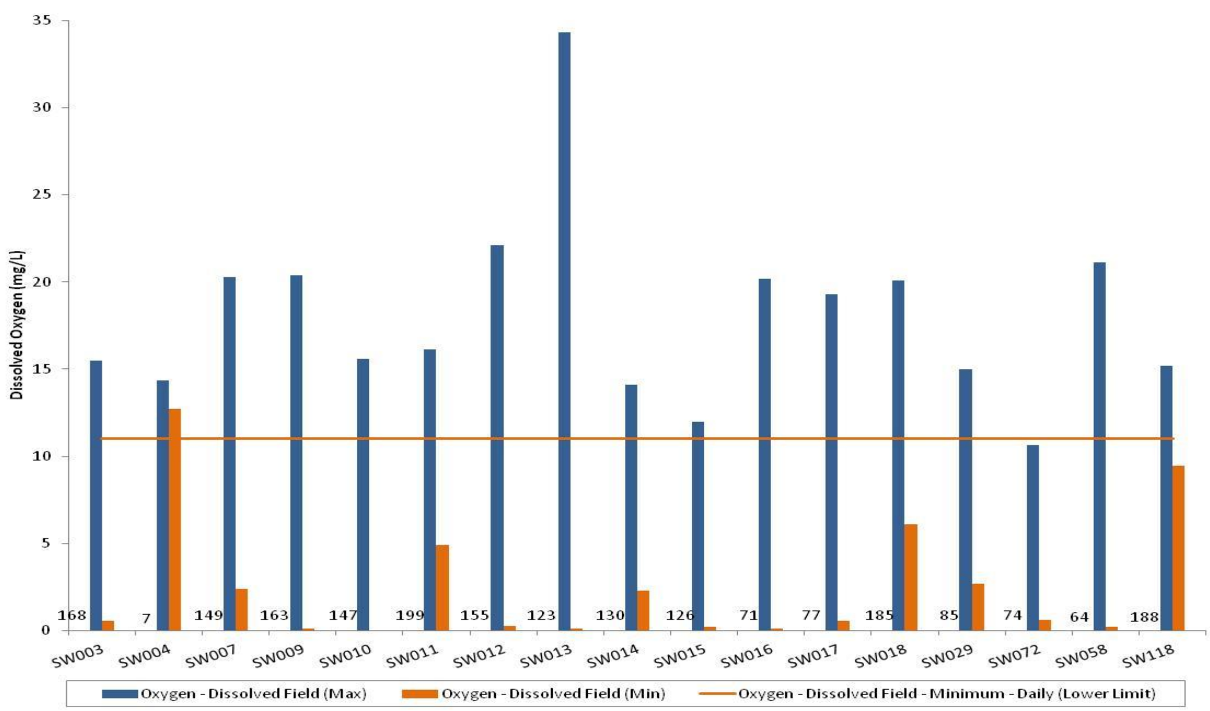

Figure 6.61 Class AA Freshwater Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2011

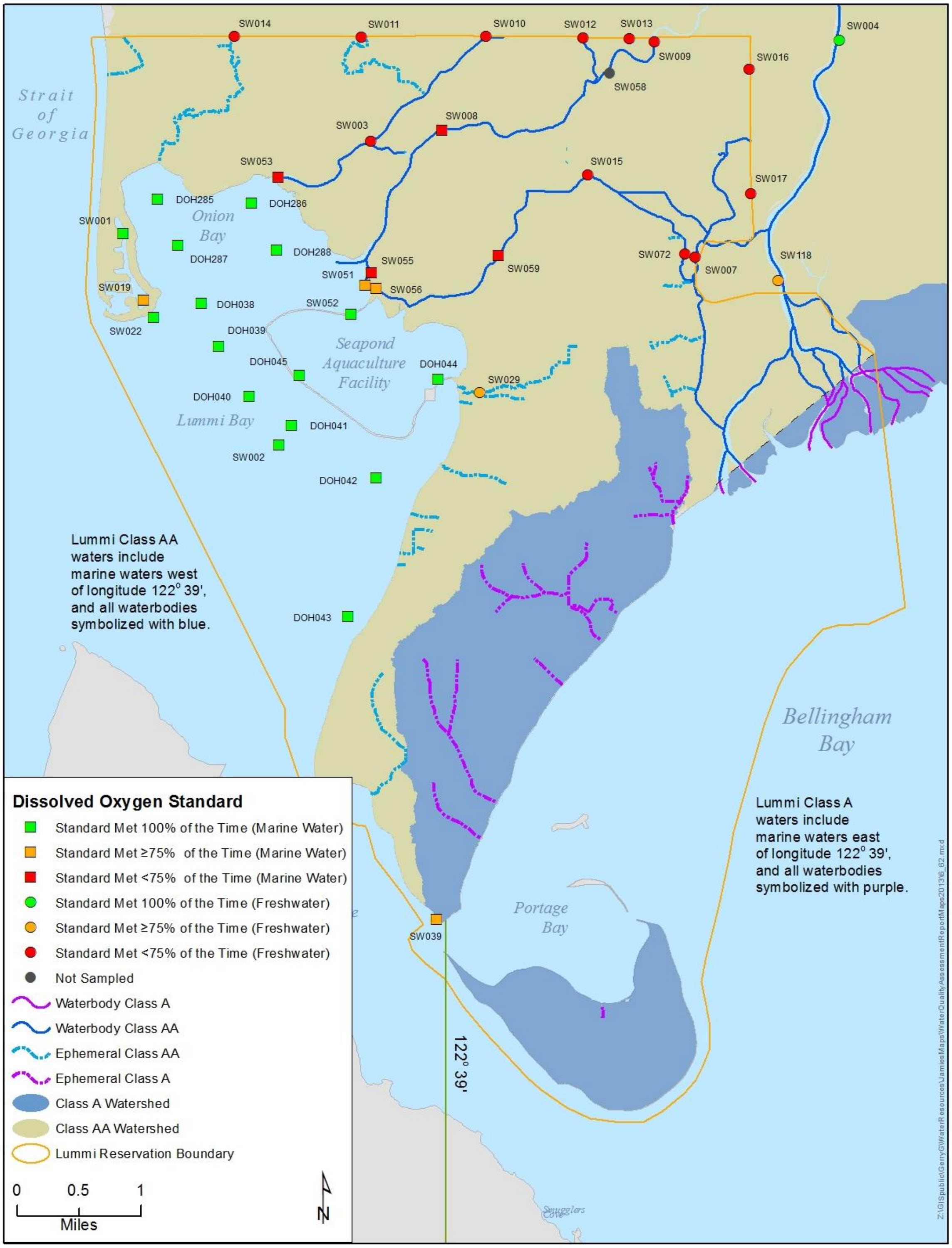

Figure 6.62 Class AA Fresh and Marine Water Dissolved Oxygen Compliance with Water Quality Standards: 2012

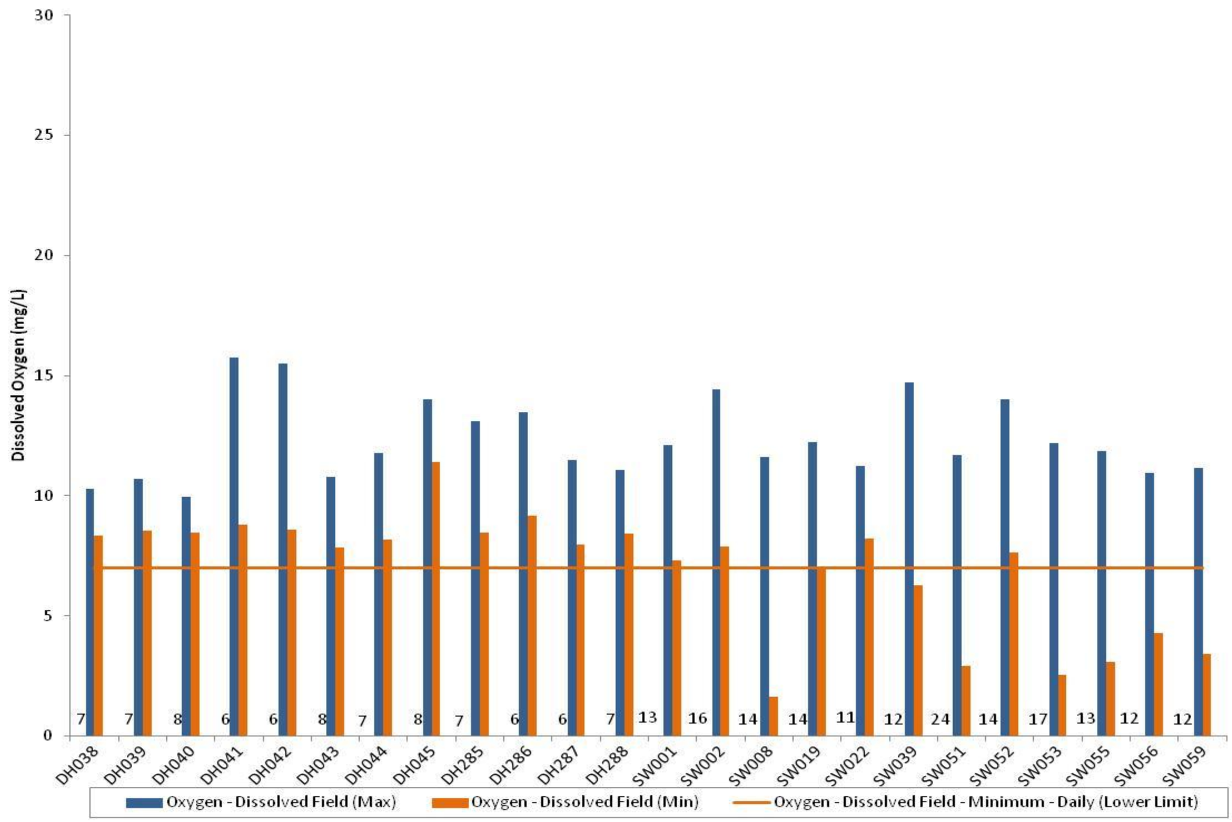

Figure 6.63 Class AA Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: 2012

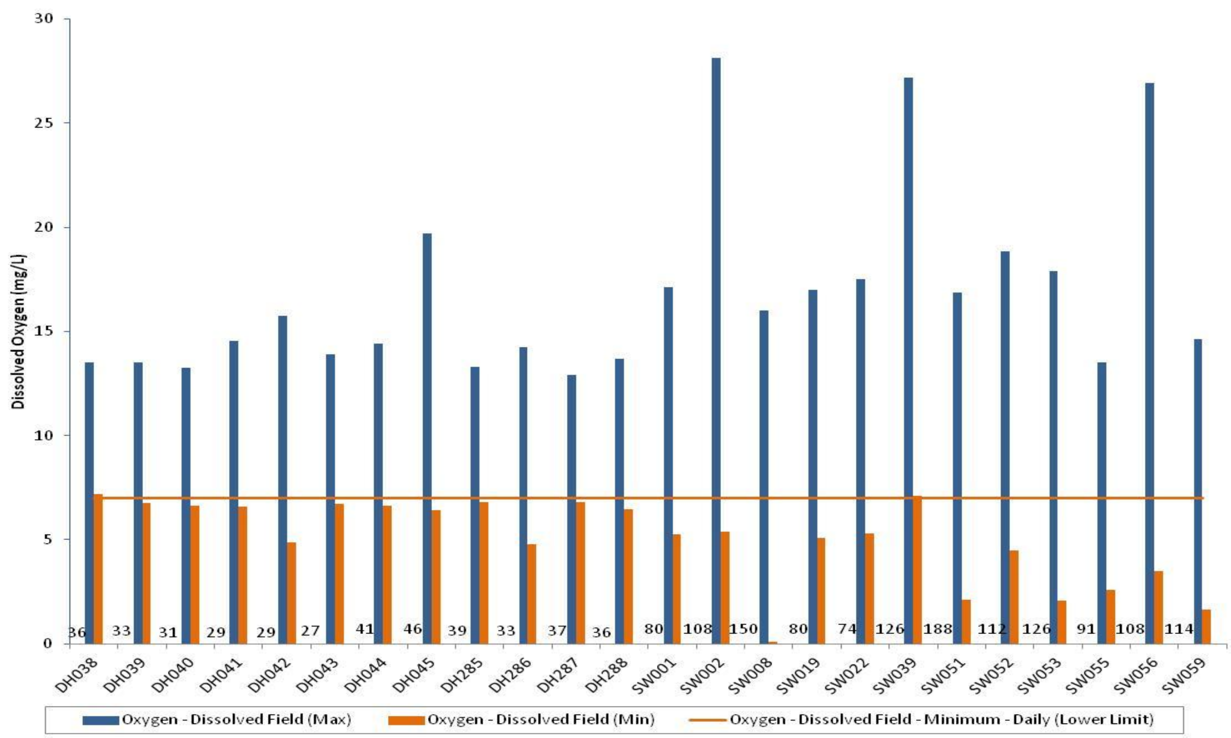

Figure 6.64 Class AA Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2011

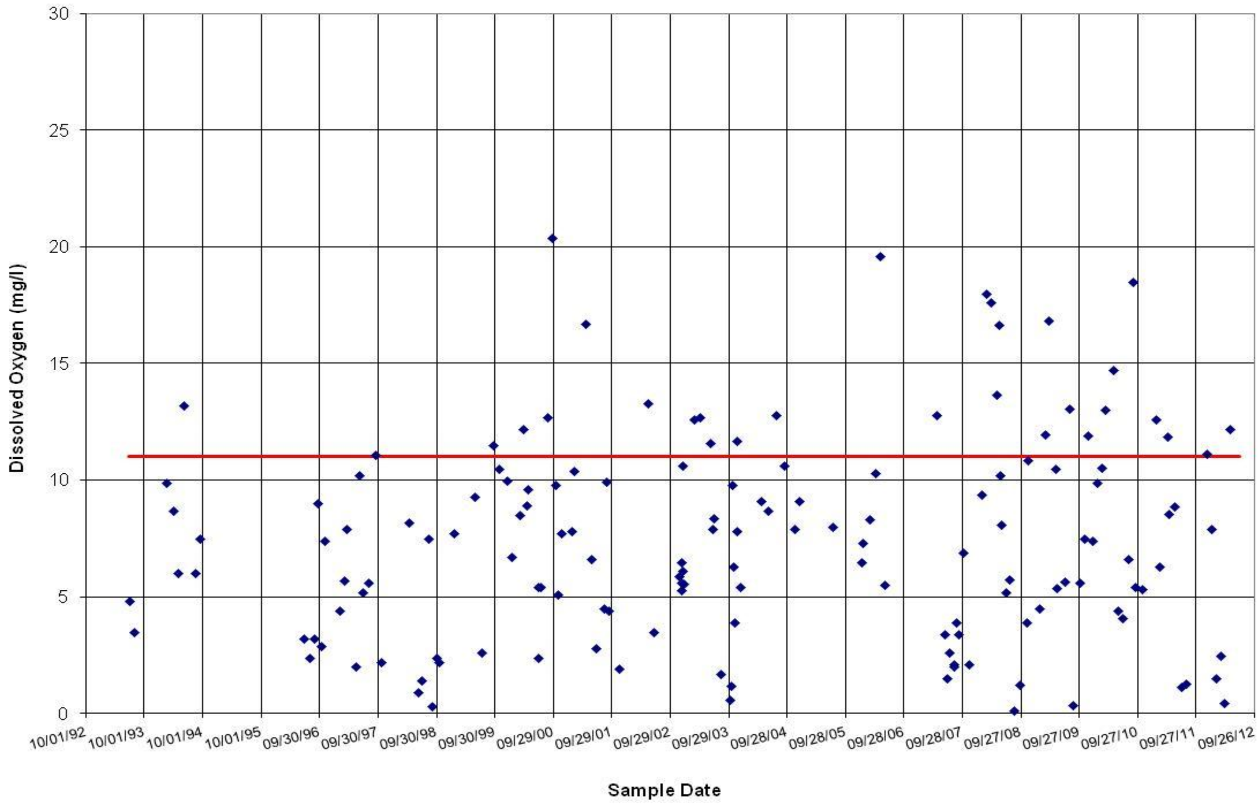

Figure 6.65 Class AA Freshwater Dissolved Oxygen Results, Site SW009

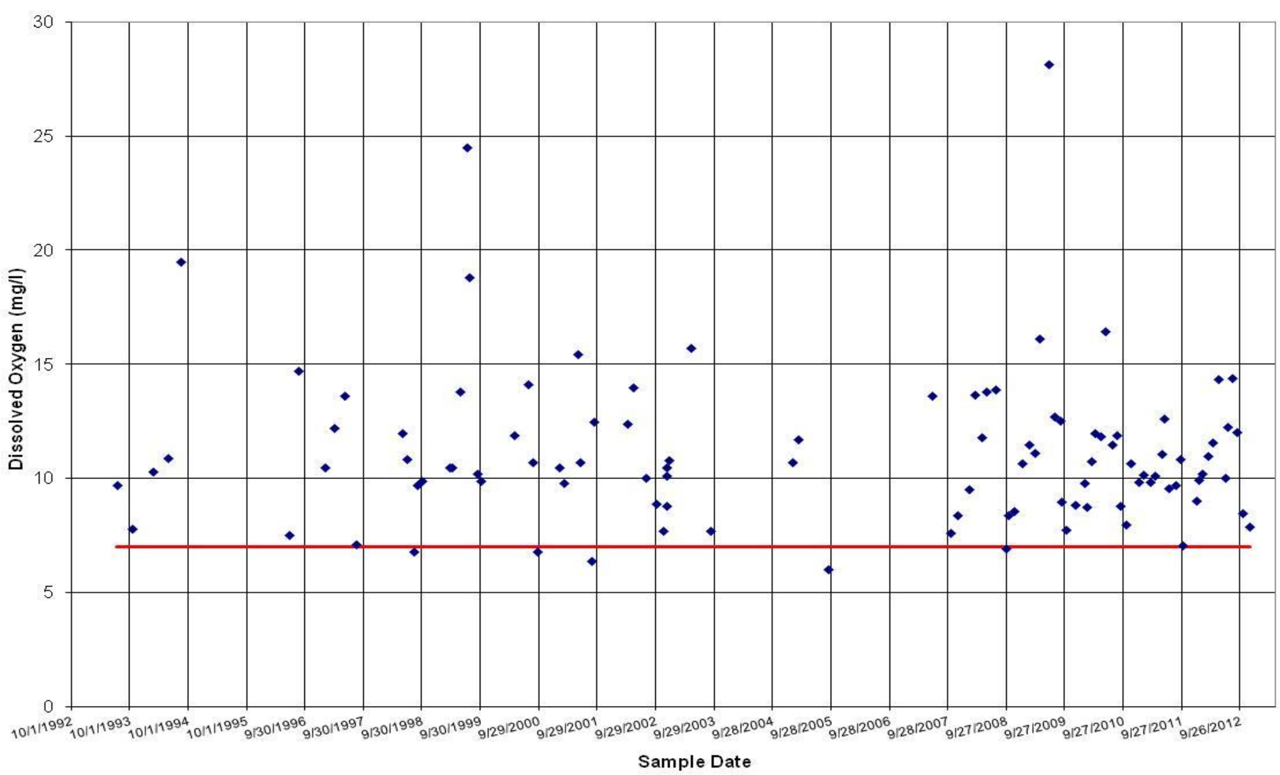

Figure 6.66 Class AA Marine Water Dissolved Oxygen Results, Site SW002

6.8.2. Class A Waters

The Class A freshwater quality standard for dissolved oxygen is a minimum value of 8.0 mg/l. As shown in Figure 6.67, the water quality samples collected during 2012 suggest that this standard was achieved at least one time for all seven sample sites. The dissolved oxygen standard was consistently achieved at only two of the seven sites, one of which was only sampled once during 2012. As shown in Figure 6.69, 3 of the 7 sites sampled during 2012 achieved the water quality standard at least 75% of the time sampled. As shown in Figure 6.68, the dissolved oxygen was above the minimum standard at least one time at each of the eight regularly sampled Class A freshwater monitoring sites over the period of record through 2011. Although Site SW024 is shown to have met the standard during the period of record, this result reflects only two samples.

The Class A marine water quality standard for dissolved oxygen is a 1-day minimum concentration of 6.0 mg/l. As shown in Figure 6.69 and Figure 6.70, the dissolved oxygen levels were consistently above the 6.0 mg/l criterion during 2012 at all seven sample sites. As shown in Figure 6.71, the dissolved oxygen levels consistently exceeded the standard at all of the Class A marine water quality monitoring sites except Site SW030 over the period of record through 2011.

As shown in Figure 6.72, the dissolved oxygen sample results for the representative Class AA freshwater site that contributes to a Class A marine water site (SW018 and SW118 on the Nooksack River along the Reservation boundary) have generally been above the minimum 11.0 mg/l Class AA threshold over the period of record. As shown in Figure 6.73, all the dissolved oxygen sample results except one in 2008 for the representative Class A marine water site (SW030 in Bellingham Bay) were above the minimum 6.0 mg/l Class A threshold over the period of record.

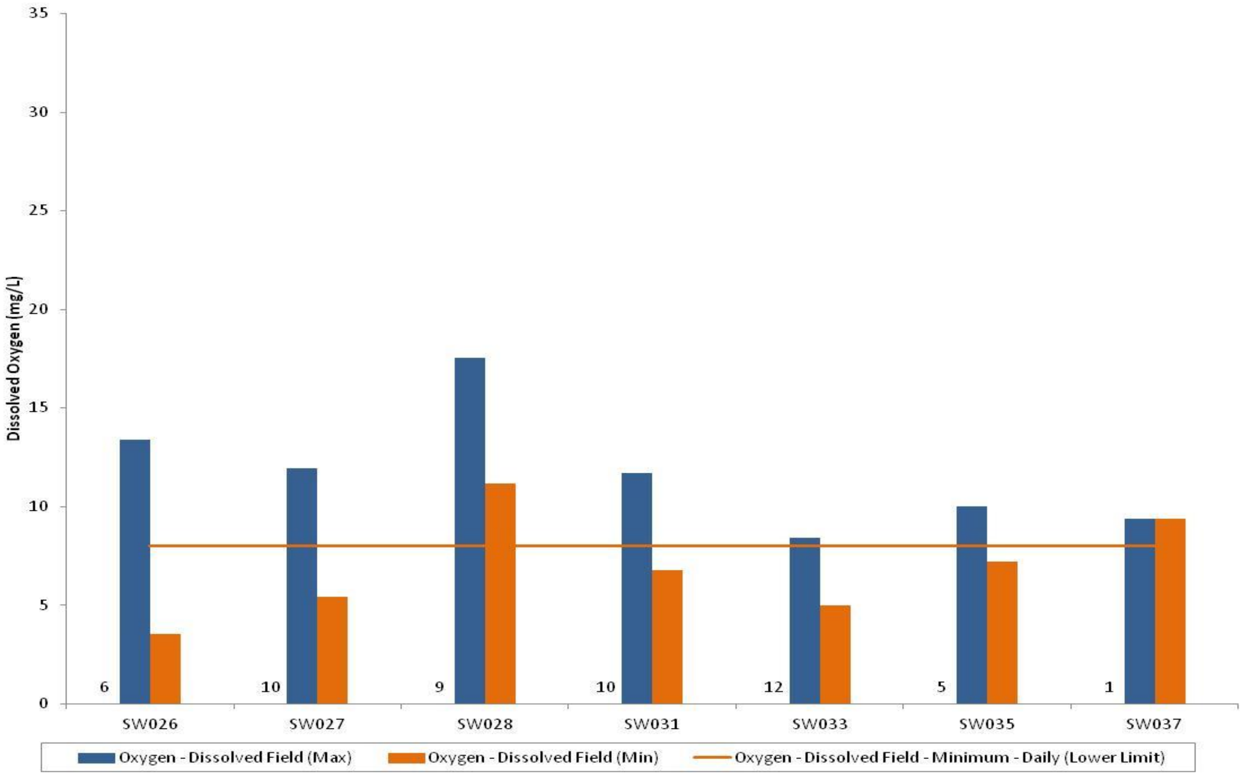

Figure 6.67 Class A Freshwater Dissolved Oxygen Results Compared With Water Quality Standards: 2012

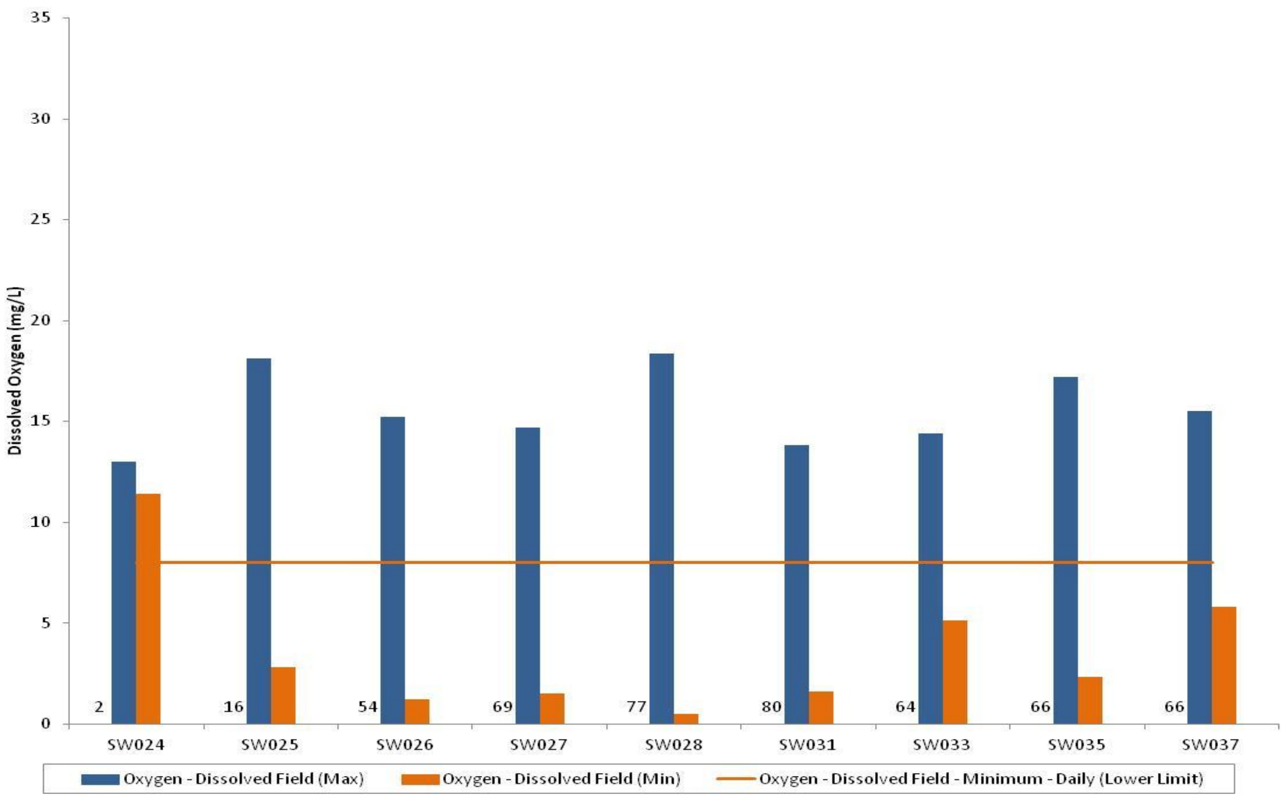

Figure 6.68 Class A Freshwater Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2011

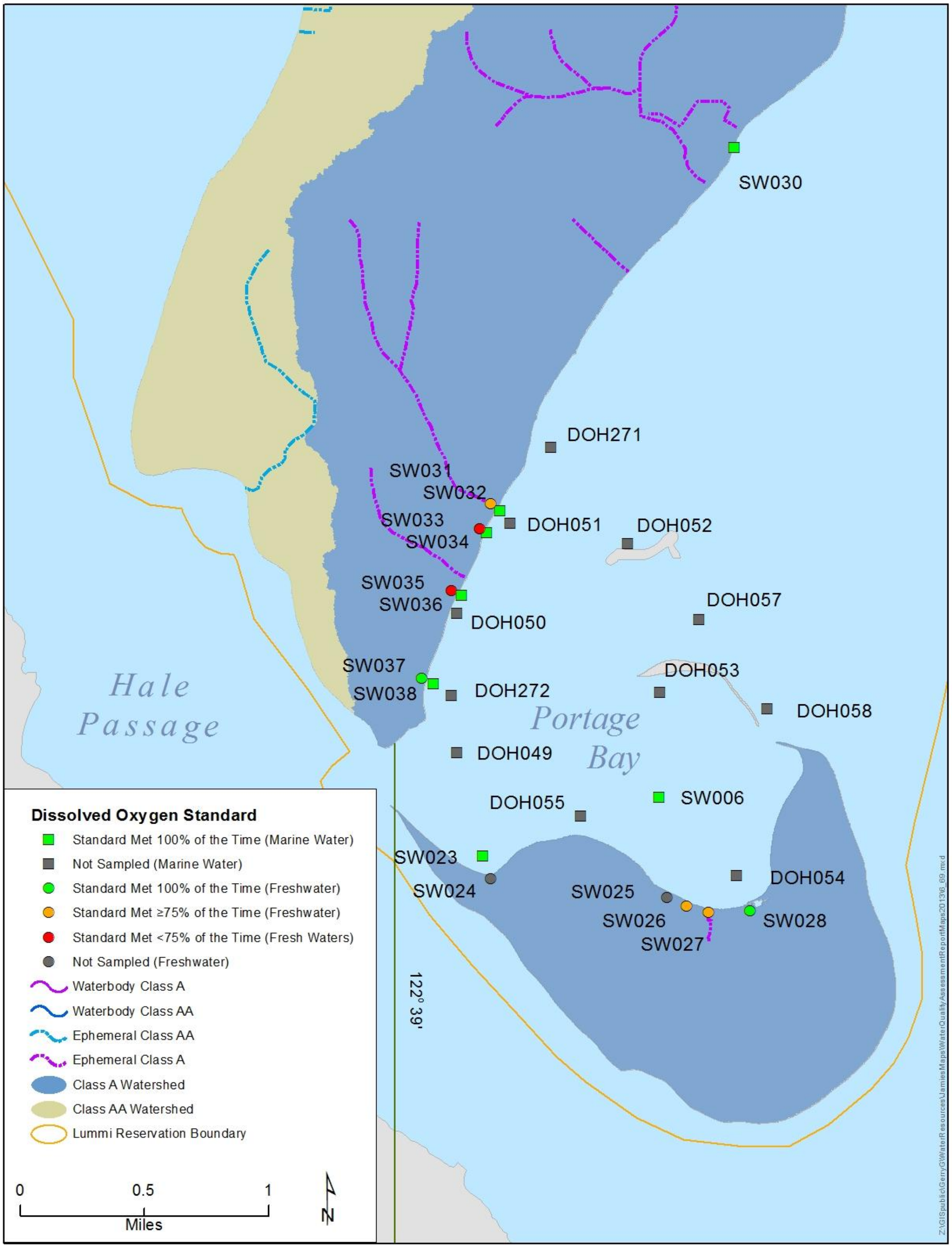

Figure 6.69 Class A Fresh and Marine Water Dissolved Oxygen Compliance with Water Quality Standards: 2012

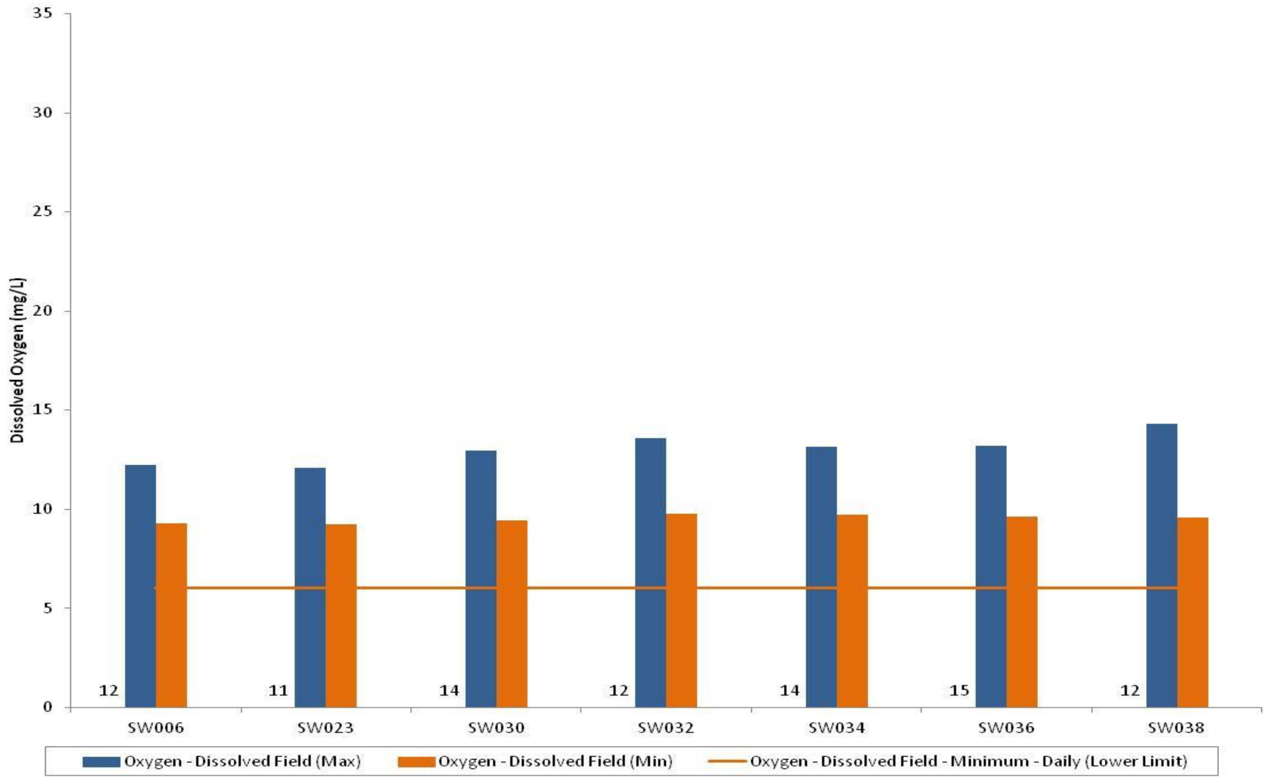

Figure 6.70 Class A Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: 2012

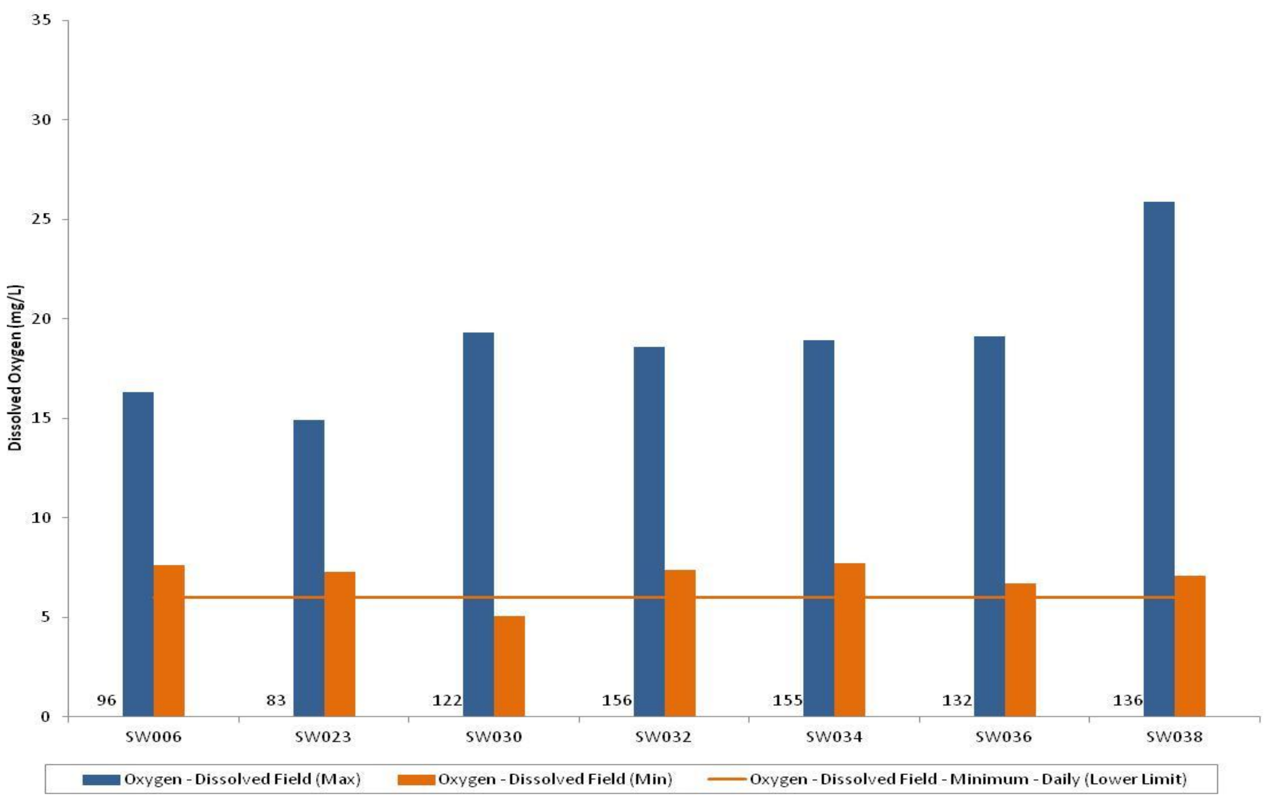

Figure 6.71 Class A Marine Water Dissolved Oxygen Results Compared with Water Quality Standards: Period of Record through 2011

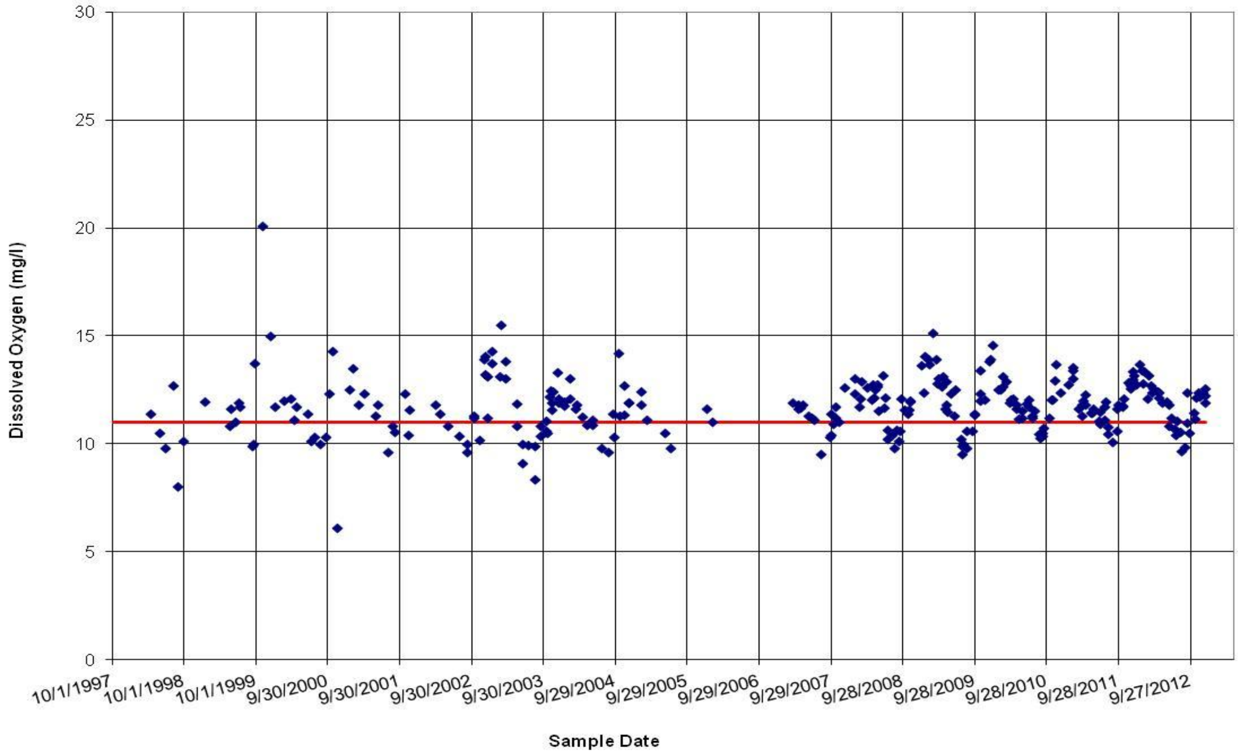

Figure 6.72 Class AA Freshwater Dissolved Oxygen Results, Site SW018/SW118

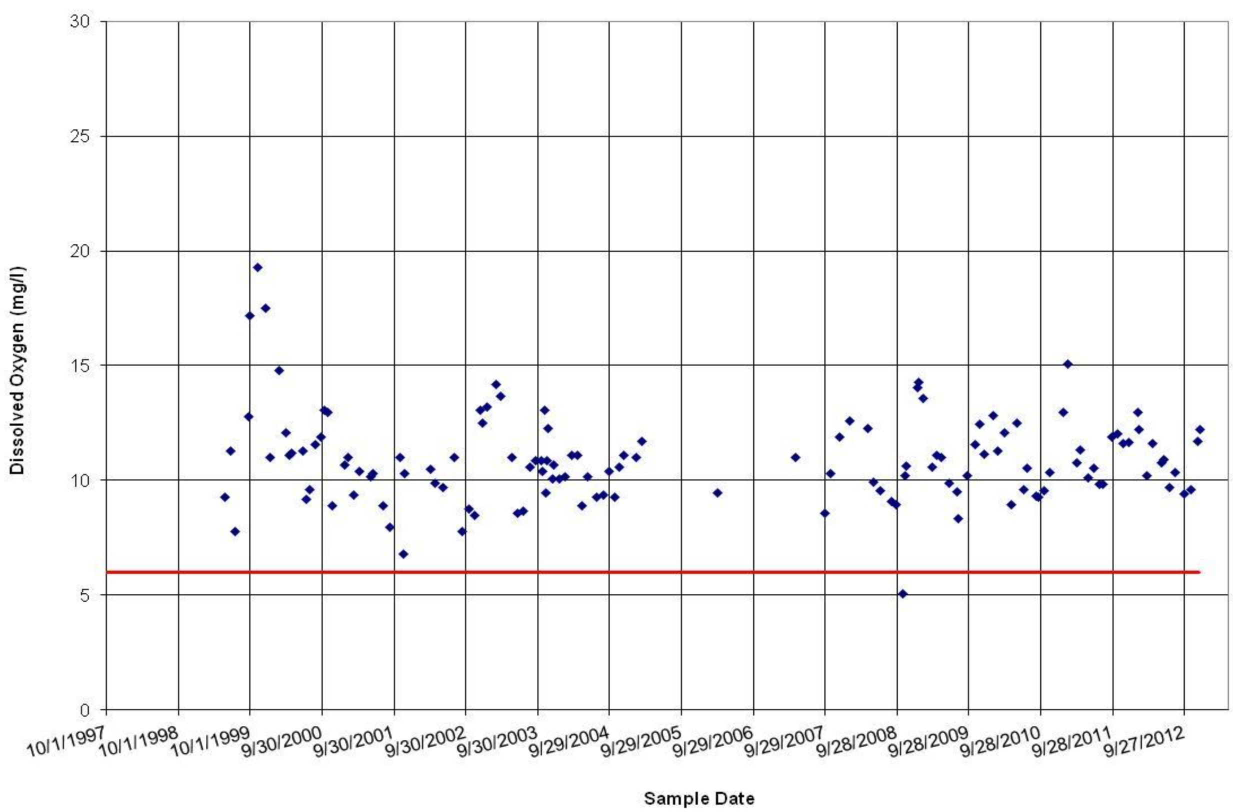

Figure 6.73 Class A Marine Water Dissolved Oxygen Results, Site SW030

6.8.3. Relationship between Dissolved Oxygen and Temperature

Water temperature influences the concentration of dissolved oxygen in a water body. In general, cold water can hold more oxygen than warm water. Adequate concentrations of dissolved oxygen are necessary for the health of fish and other aquatic organisms and to prevent offensive odors caused by anaerobic bacteria. Low dissolved oxygen levels can impact organisms' growth rates, swimming ability, susceptibility to diseases, and the ability to survive other environmental stressors and pollutants.

As summarized in Table 6.5, the relation between temperature and dissolved oxygen varies from site to site and there is generally a poor relationship between the two water chemistry variables. The best relationship, as defined by the highest coefficient of determination (r^2) and slope of the best-fit line close to 1, is for Site DH044 (inside Lummi Seaponds Aquaculture Dike).

Table 6.5 Relation Between Dissolved Oxygen and Temperature

Sample Site Number	Number of Sample Pairs	Slope	Intercept	R-Square
Fresh Water				
SW003	223	-0.17	9.48	0.16
SW007	222	-0.29	14.07	0.36
SW009	218	-0.13	8.55	0.02
SW010	184	-0.19	7.73	0.09
SW011	360	-0.31	13.54	0.33
SW012	232	-0.14	9.15	0.04
SW013	154	0.54	1.90	0.19
SW014	193	-0.44	12.65	0.50
SW015	176	-0.05	6.73	0.01
SW016	90	-0.08	9.01	0.01
SW017	93	0.07	6.35	0.01
SW018	240	-0.23	13.66	0.37
SW025	18	0.56	6.24	0.25
SW026	71	-0.11	11.64	0.07
SW027	115	-0.32	13.62	0.28
SW028	111	-0.14	13.73	0.08
SW029	111	-0.45	14.41	0.46
SW032	180	-0.06	11.69	0.02
SW034	201	-0.06	11.68	0.02
SW036	156	-0.12	12.37	0.11
SW038	147	-0.13	12.50	0.08
SW058	68	-0.28	9.80	0.05
SW072	98	-0.09	5.74	0.05
SW118	327	-0.23	14.03	0.75
Marine Water				
DH038	61	-0.07	9.79	0.02
DH039	52	-0.04	9.99	0.01
DH040	51	0.00	9.44	0.00
DH041	41	0.32	6.60	0.23
DH042	41	0.08	9.01	0.02
DH043	41	0.04	9.42	0.00
DH044	68	-0.24	12.58	0.73
DH045	83	-0.16	14.22	0.09
DH285	56	0.02	9.75	0.00
DH286	41	0.05	9.53	0.02
DH287	50	-0.08	10.21	0.03
DH288	49	-0.08	10.67	0.03
SW001	128	0.01	9.29	0.00
SW002	188	0.14	9.36	0.04
SW006	142	-0.07	11.30	0.04
SW008	194	-0.23	10.33	0.33
SW019	118	-0.08	10.04	0.03
SW022	110	-0.07	10.77	0.02
SW023	120	-0.13	11.75	0.15
SW030	143	-0.17	12.87	0.20
SW031	123	-0.17	11.46	0.09
SW033	108	-0.09	9.40	0.04
SW035	79	0.06	9.00	0.01
SW037	77	-0.16	11.28	0.15
SW039	147	0.20	8.40	0.08
SW051	216	-0.16	11.15	0.25
SW052	148	-0.19	12.52	0.38
SW053	187	-0.19	11.39	0.29
SW055	106	-0.11	8.85	0.08
SW056	140	0.16	7.79	0.09
SW059	170	-0.17	8.94	0.13

6.9.pH Results

The water quality standards for pH (hydrogen ion concentration) set a range of acceptable values. If the maximum or minimum measured pH is not within the specified range, the sample results indicate that the characteristic uses of the water body are not supported.

6.9.1. Class AA Waters

The Class AA freshwater quality standard for pH is not less than 6.5 and not more than 8.5. As shown in Figure 6.74, the water quality data collected during 2012 indicate that the pH standard was achieved at only 5 of the 15 sample sites. As shown in Figure 6.76, 5 of the 15 sample sites that did not achieve the water quality standard 100% of the time sampled achieved the standard at least 75% of the time during 2012. As shown in Figure 6.75, the pH standard was always achieved at only 1 of the 16 sample sites (SW004) over the period of record. The highest pH (most alkaline) levels were measured at the Nooksack River site (SW018/SW118) and the lowest pH (most acidic) levels were measured in a perennial stream (SW029) that drains an undeveloped portion of the Reservation.

The Class AA marine water quality standard for pH is not less than 7.0 and not more than 8.5. As shown in Figure 6.77, the water quality data collected during 2012 indicate that this standard was achieved at 12 of the 24 sample sites. As shown in Figure 6.76, of the 12 sites that did not achieve the water quality standard 100% of the time sampled during 2012, 8 of those sites achieved the standard at least 75% of the time sampled. As shown in Figure 6.78, 8 of the 24 sample sites met the pH standard over the period of record. The highest pH value was measured at the sample site along the Lummi River at the Hillaire Road Bridge (SW008) and the lowest pH value was measured at the mouth of the Lummi River before the river discharges to Lummi Bay (SW051).

As shown in Figure 6.79, the pH sample results for the representative Class AA freshwater site that contributes to a Class AA marine water site (SW009) have generally been more than 6.5 and less than 8.5 units. However, when there were multiple measurements during a particular day, the results were averaged in the data shown in Figure 6.79.

As shown in Figure 6.80, the pH sample results for the representative Class AA marine water site (SW002) have always been above the 7.0 pH threshold but have exceeded the 8.5 pH units threshold on three occasions over the period of record. Figure 6.79 and Figure 6.80 also show the gap in the pH data record that resulted from a combination of equipment malfunctions and staff changes before being measured consistently in 2008.

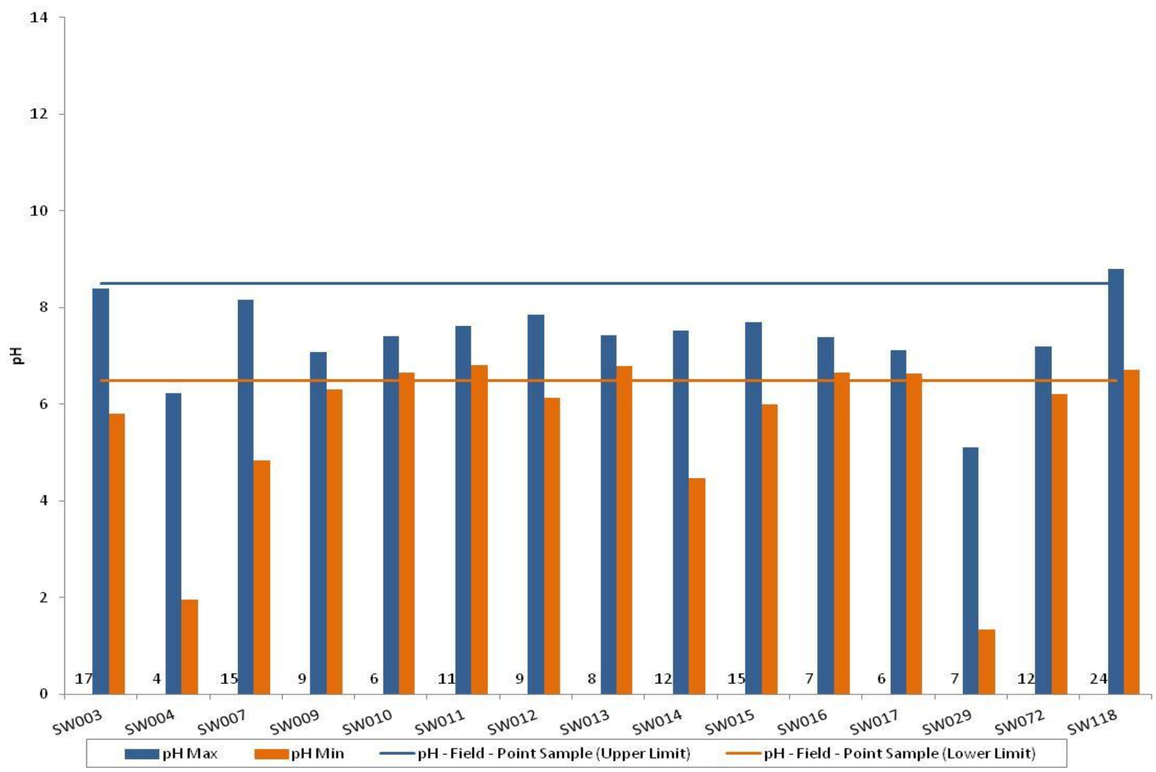

Figure 6.74 Class AA Freshwater pH Results Compared with Water Quality Standards: 2012

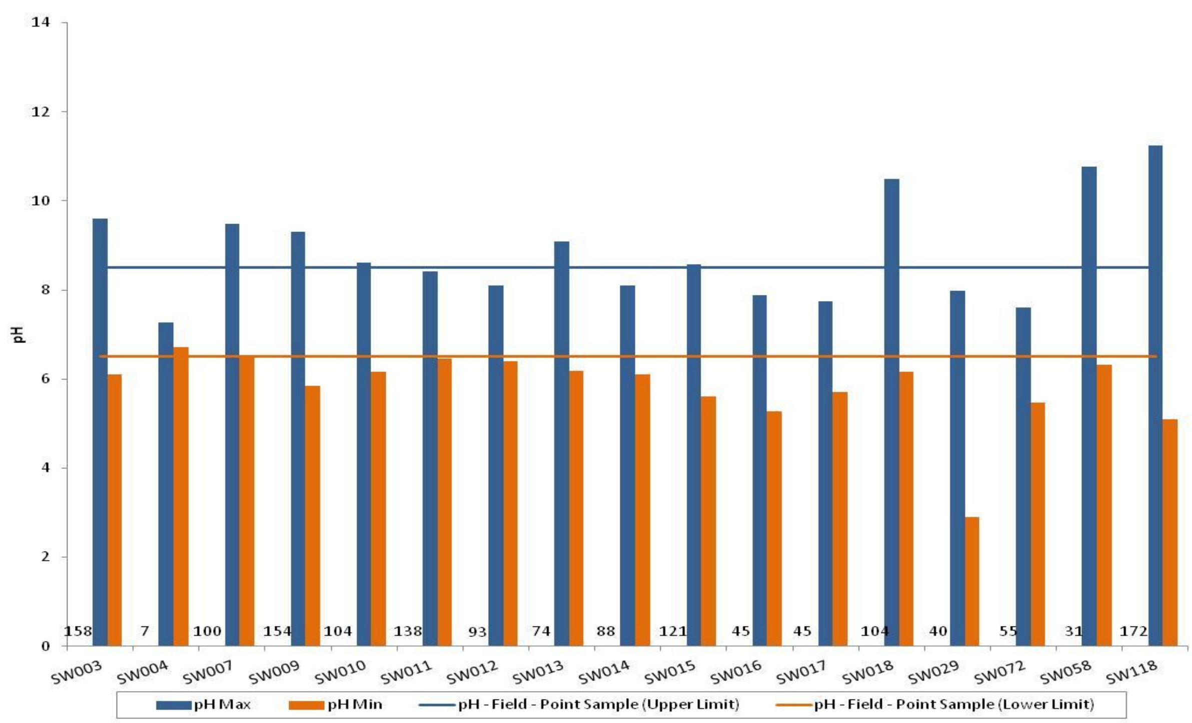

Figure 6.75 Class AA Freshwater pH Results Compared with Water Quality Standards: Period of Record through 2011

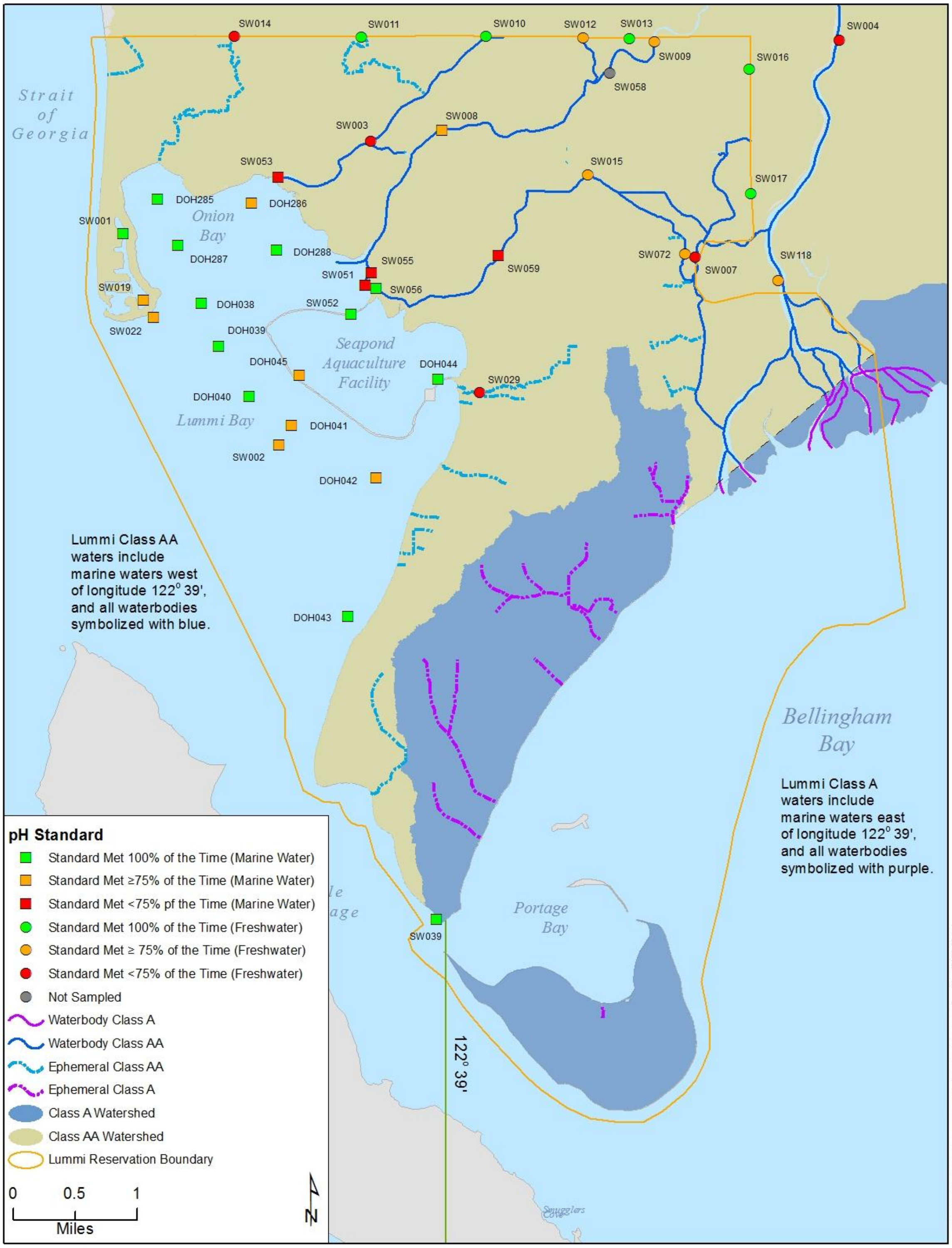

Figure 6.76 Class AA Freshwater and Marine Water pH Compliance with Water Quality Standards: 2012

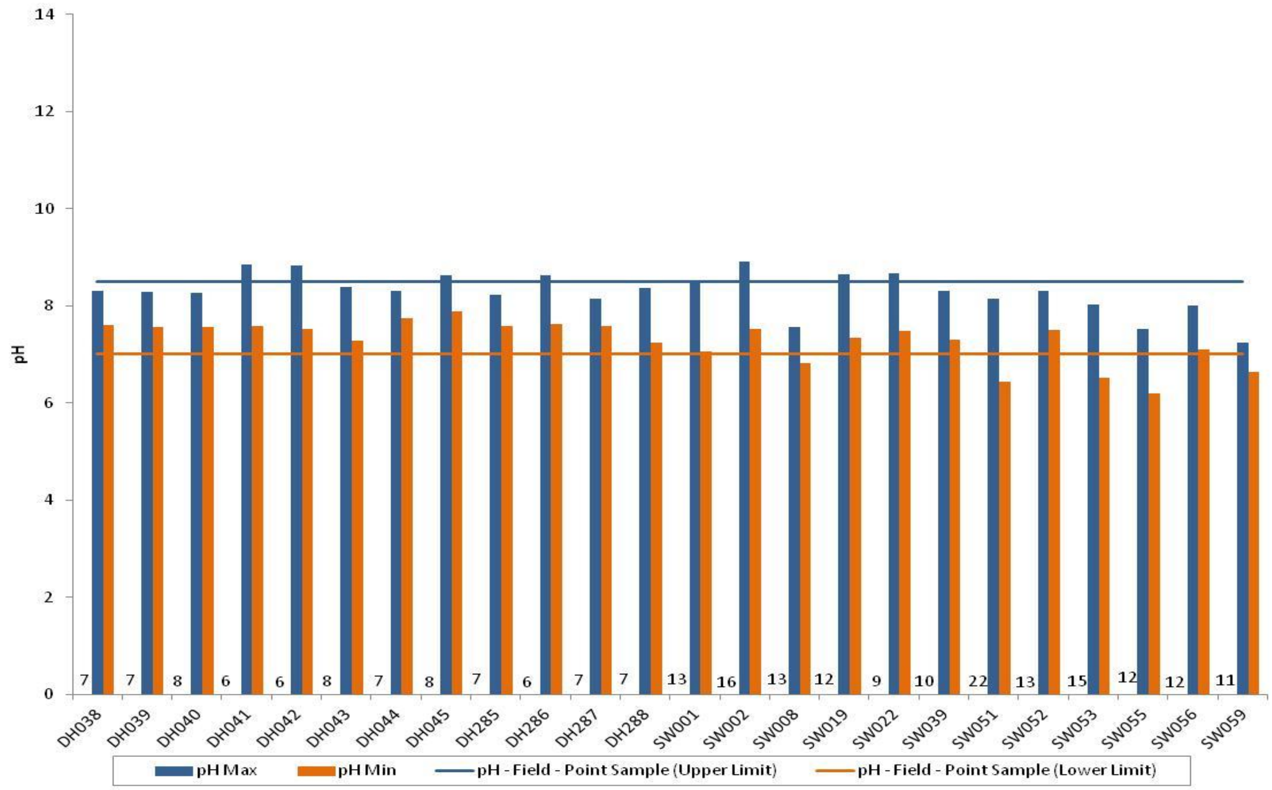

Figure 6.77 Class AA Marine Water pH Results Compared with Water Quality Standards: 2012

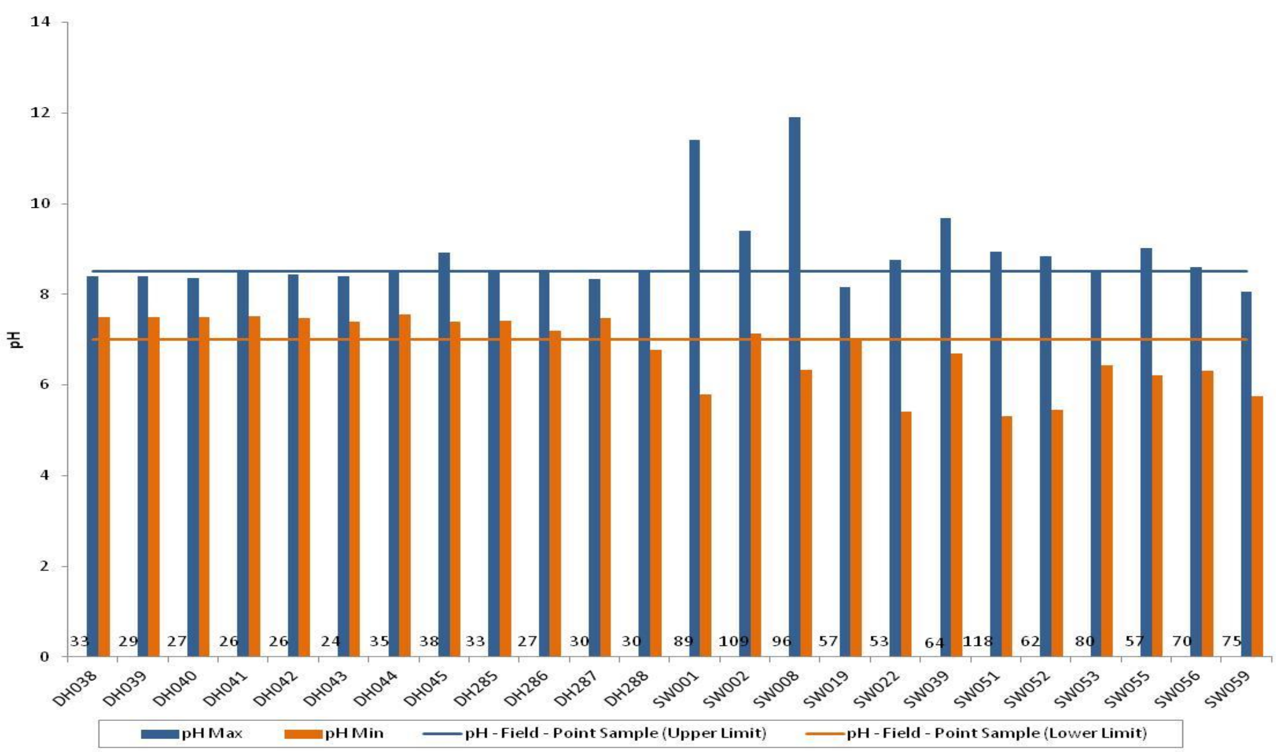

Figure 6.78 Class AA Marine Water pH Results Compared with Water Quality Standards: Period of Record through 2011

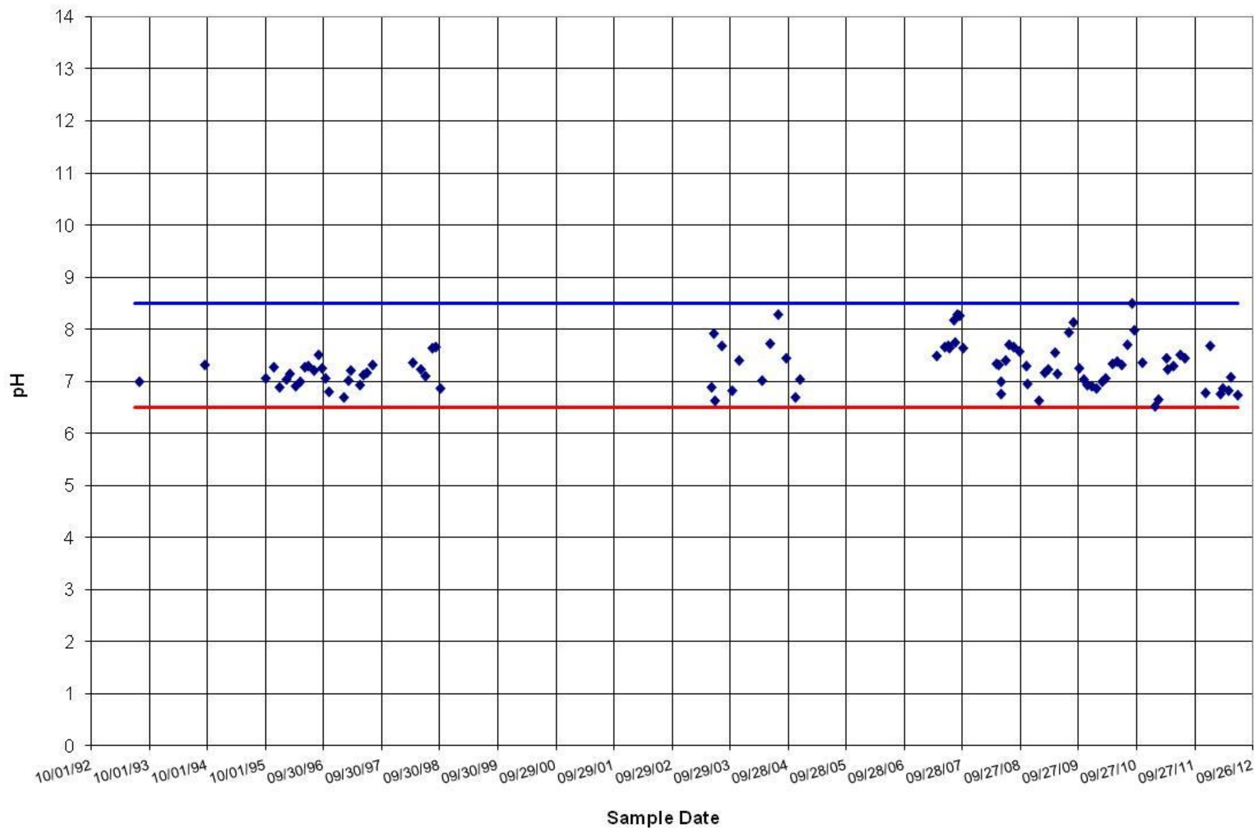

Figure 6.79 Class AA Freshwater pH Results, Site SW009

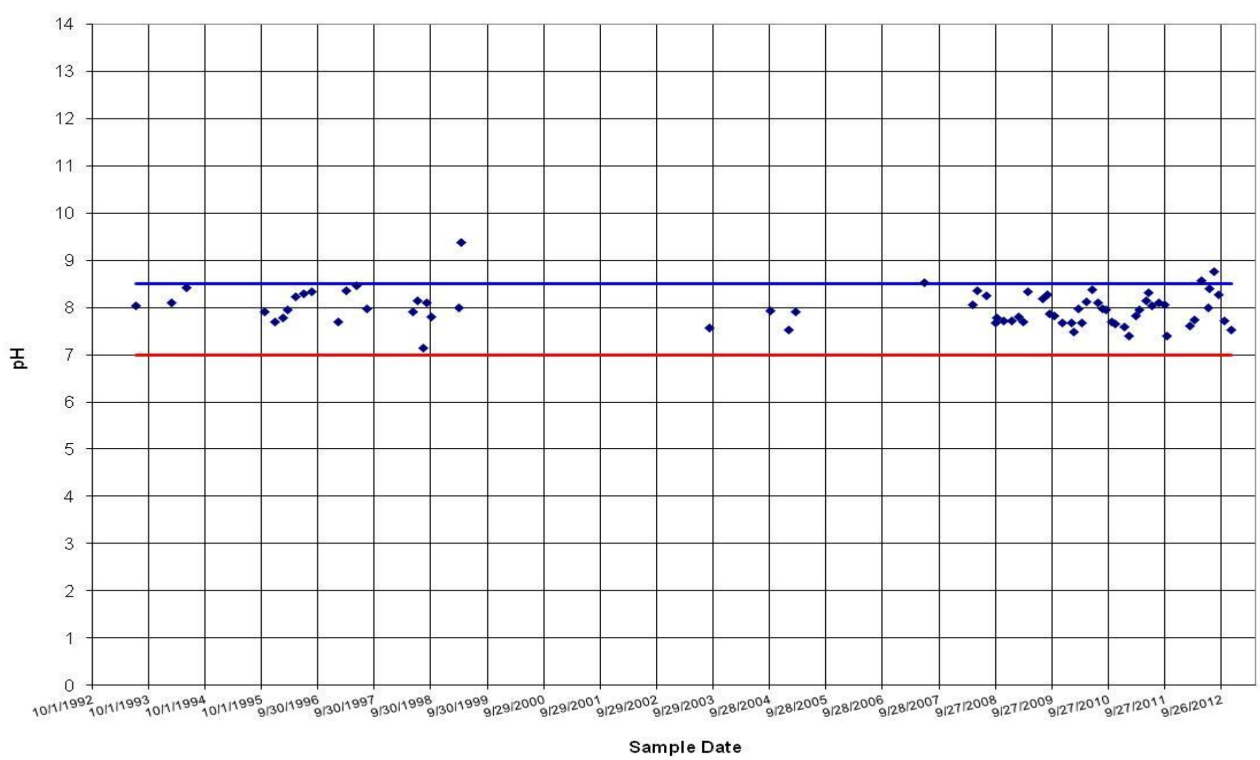

Figure 6.80 Class AA Marine Water pH Results, Site SW002

6.9.2. Class A Waters

The Class A freshwater quality standard for pH is not less than 6.5 and not more than 8.5. As shown in Figure 6.81, the water quality data collected during 2012 indicate that the standard was achieved at 2 of the 6 sample sites. As shown in Figure 6.83, of the 4 sites that did not achieve the water quality standard 100% of the time sampled during 2012, 1 of those sites achieved the standard at least 75% of the time sampled. As shown in Figure 6.82, the pH standard was achieved at Site SW024 and Site SW037 for the period of record. Site SW037 is along a relatively dense residential area along the Portage Bay shoreline. The lowest pH values were measured at Site SW033, which drains a wooded area along the Lummi Peninsula.

The Class A marine water quality standard for pH is not less than 7.0 and not more than 8.5. As shown in Figure 6.84, the water quality data collected during 2012 indicate that this standard was achieved at 4 of the 7 Class A marine water quality sample sites. As shown in Figure 6.83, all 3 sites sampled during 2012 that did not achieve the water quality standard 100% of the time sampled achieved the standard at least 75% of the time sampled. As shown in Figure 6.85, none of the sample sites met the standard consistently over the period of record. At 6 of the 7 sites, the pH was above the maximum pH threshold and below the minimum pH threshold at least once. The highest pH value over the period of record was measured at the sample site located in Portage Bay along Lummi Shore Road (SW032) and the lowest pH value was measured in another part of Portage Bay just offshore of Site SW024 (SW023).

As shown in Figure 6.86, the pH sample results for the representative Class AA freshwater site that contributes to a Class A marine water site (SW018/SW118 on the Nooksack River along the Reservation boundary) have generally met the standard over the period of record but there have been several measurements both above and below the standard. As shown in Figure 6.87, the pH sample results for the representative Class A marine water site (SW030 in Bellingham Bay) have generally met the standard but there are several measurements below the 7.0 pH units threshold over the period of record. Similar to the Class AA pH results, Figure 6.84 and Figure 6.85 show the gap in the pH data record that resulted from a combination of equipment malfunctions and staff changes.

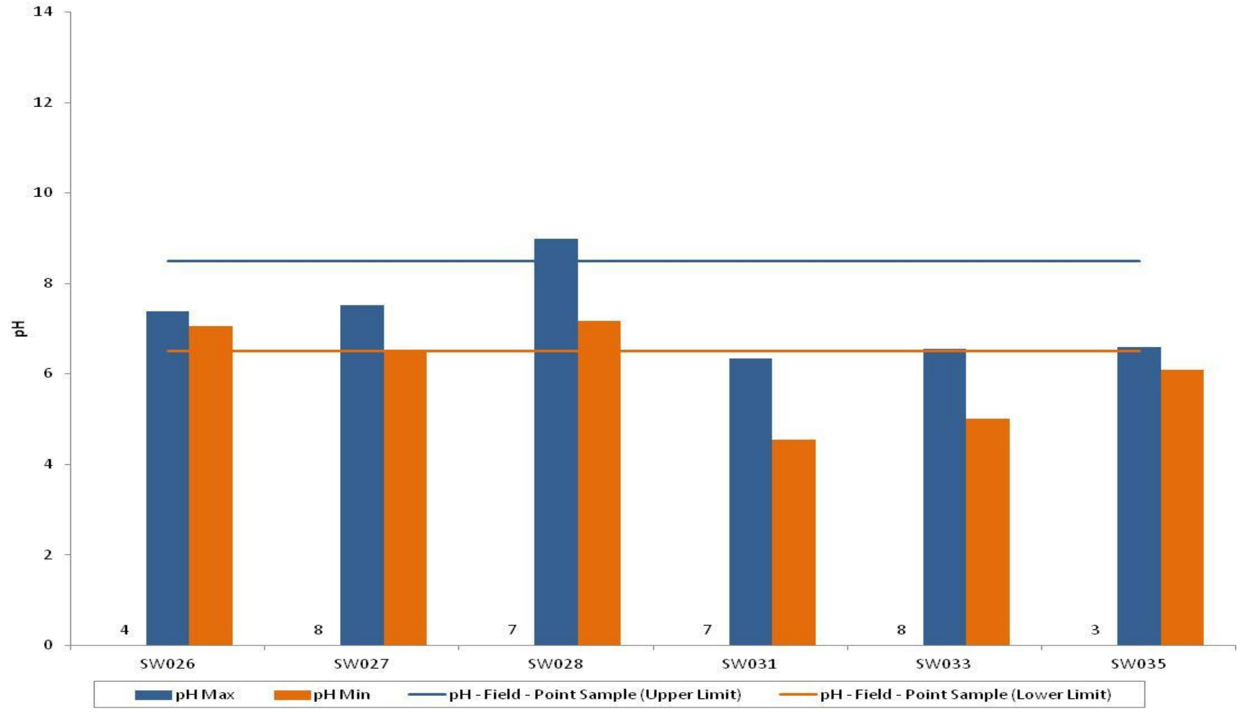

Figure 6.81 Class A Freshwater pH Results Compared with Water Quality Standards: 2012

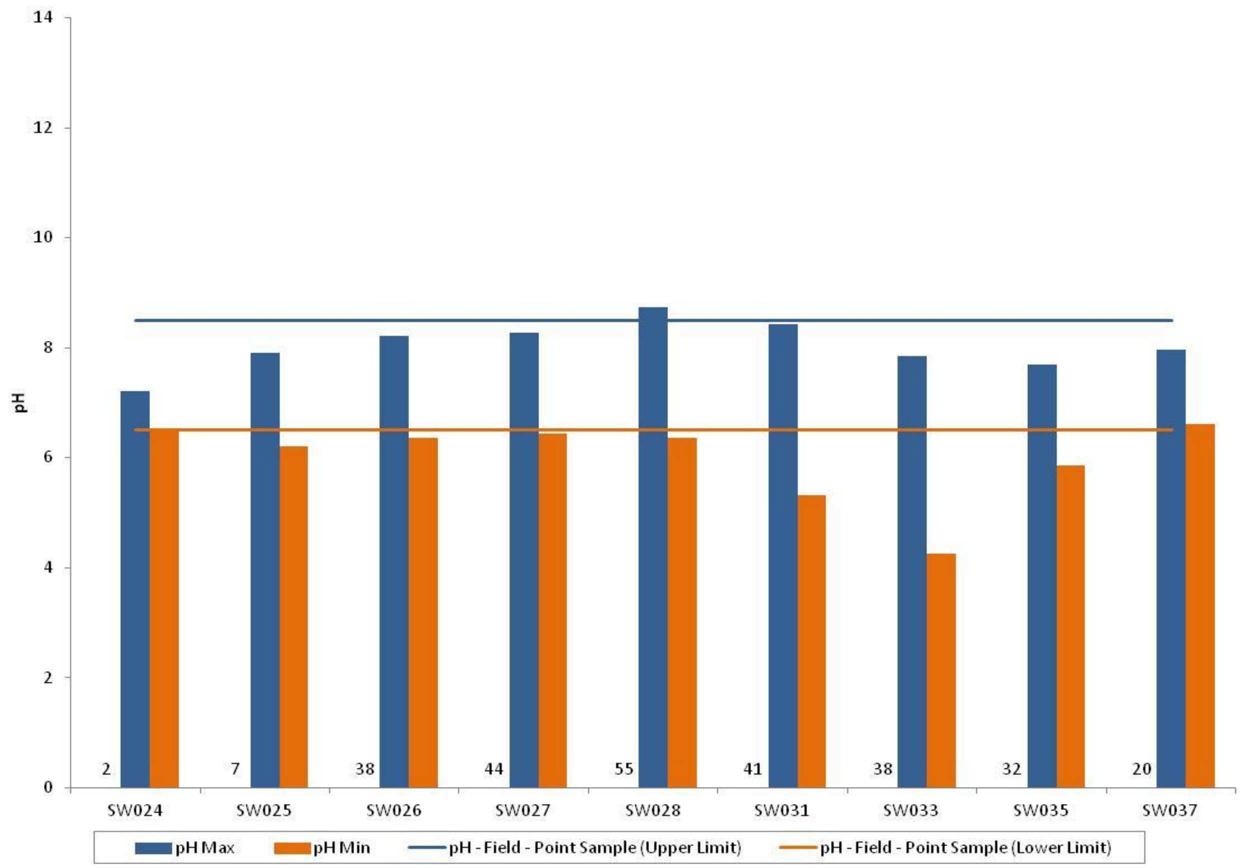

Figure 6.82 Class A Freshwater pH Results Compared with Water Quality Standards: Period of Record through 2012

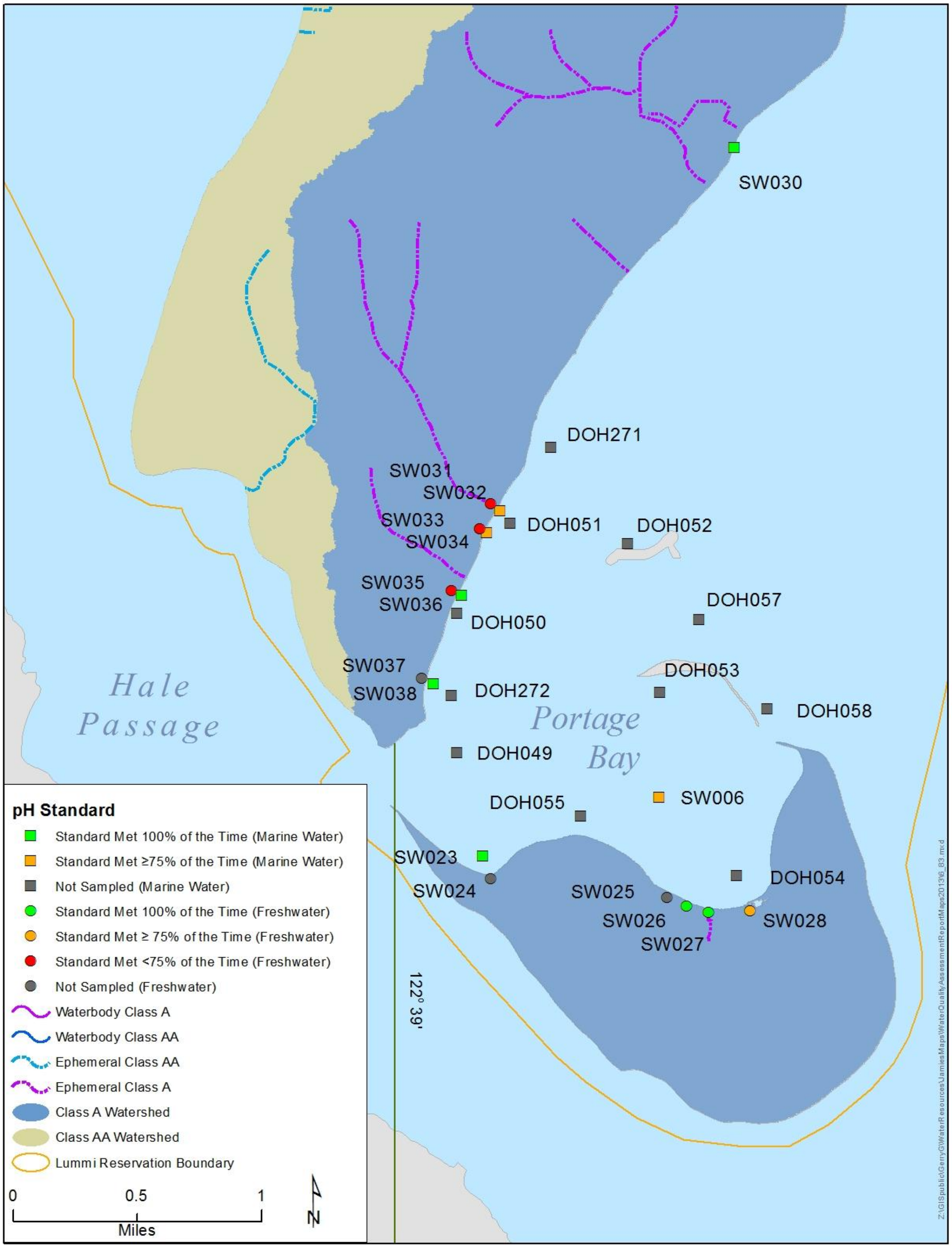

Figure 6.83 Class A Freshwater and Marine Water pH Compliance with Water Quality Standards: 2012

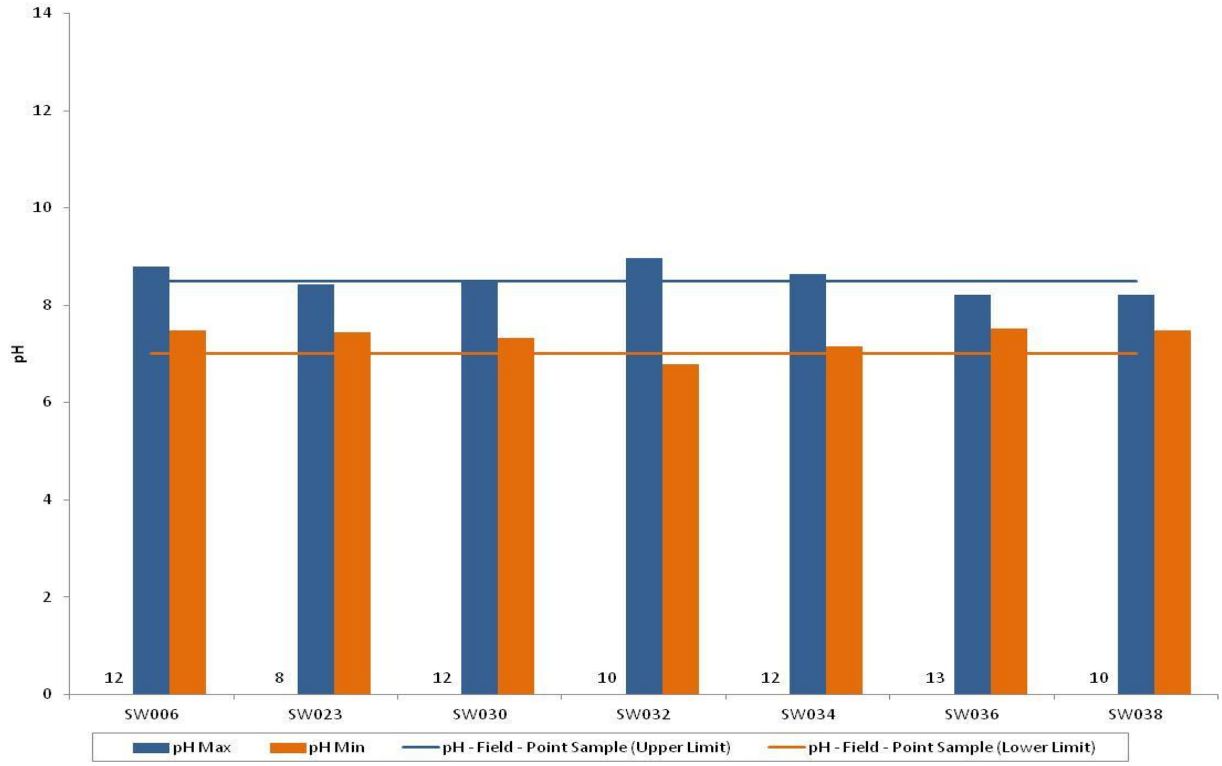

Figure 6.84 Class A Marine Water pH Results Compared with Water Quality Standards: 2012

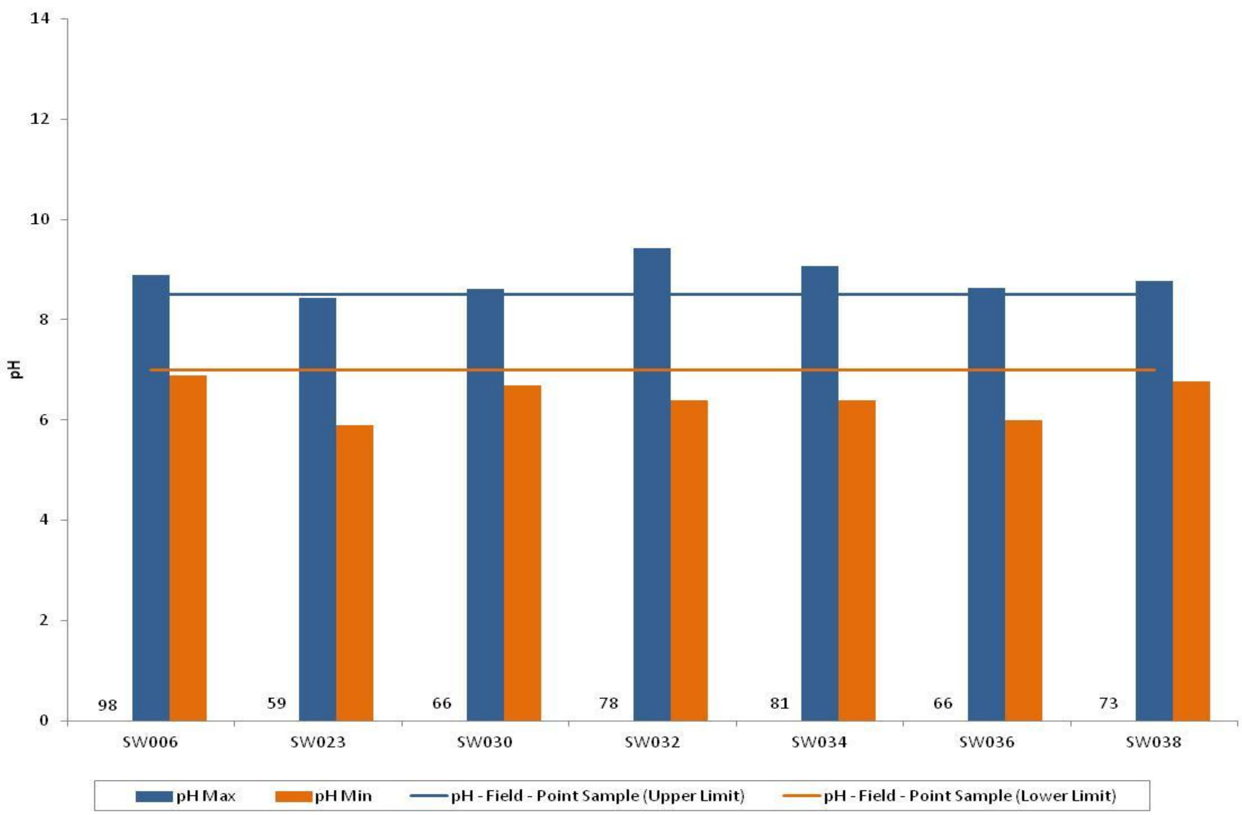

Figure 6.85 Class A Marine Water pH Results Compared with Water Quality Standards: Period of Record through 2011

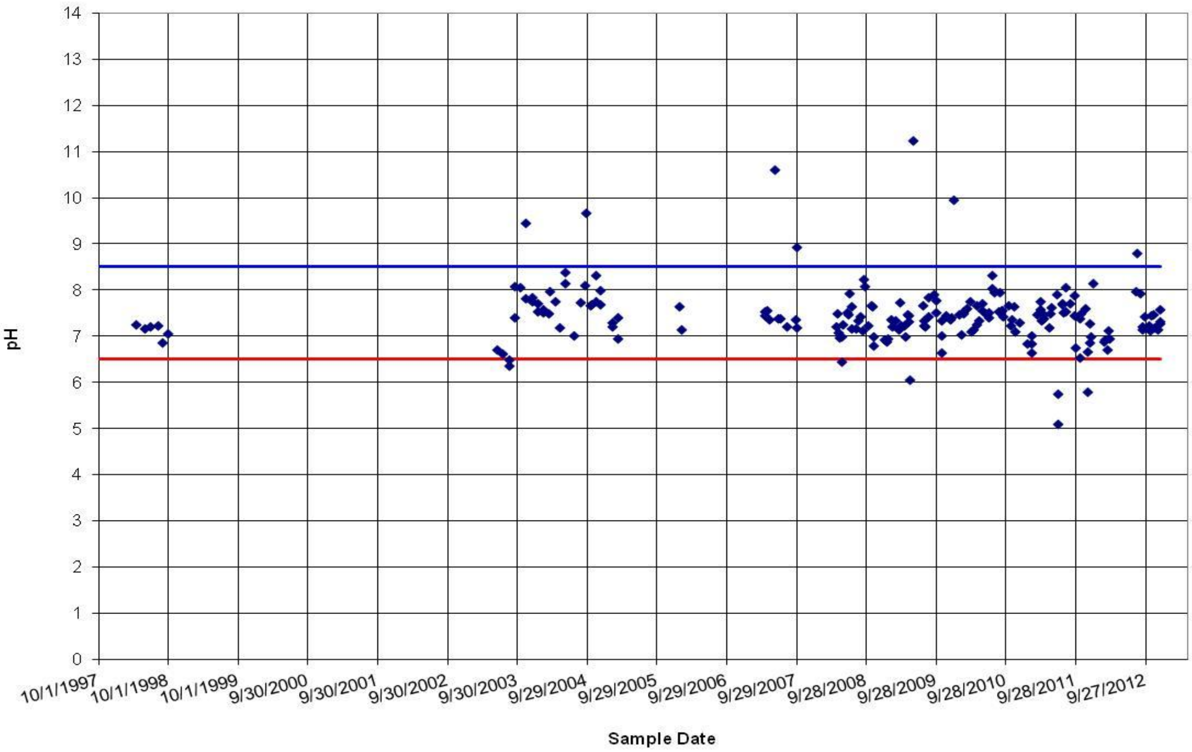

Figure 6.86 Class AA Freshwater pH Results, Site SW018/SW118

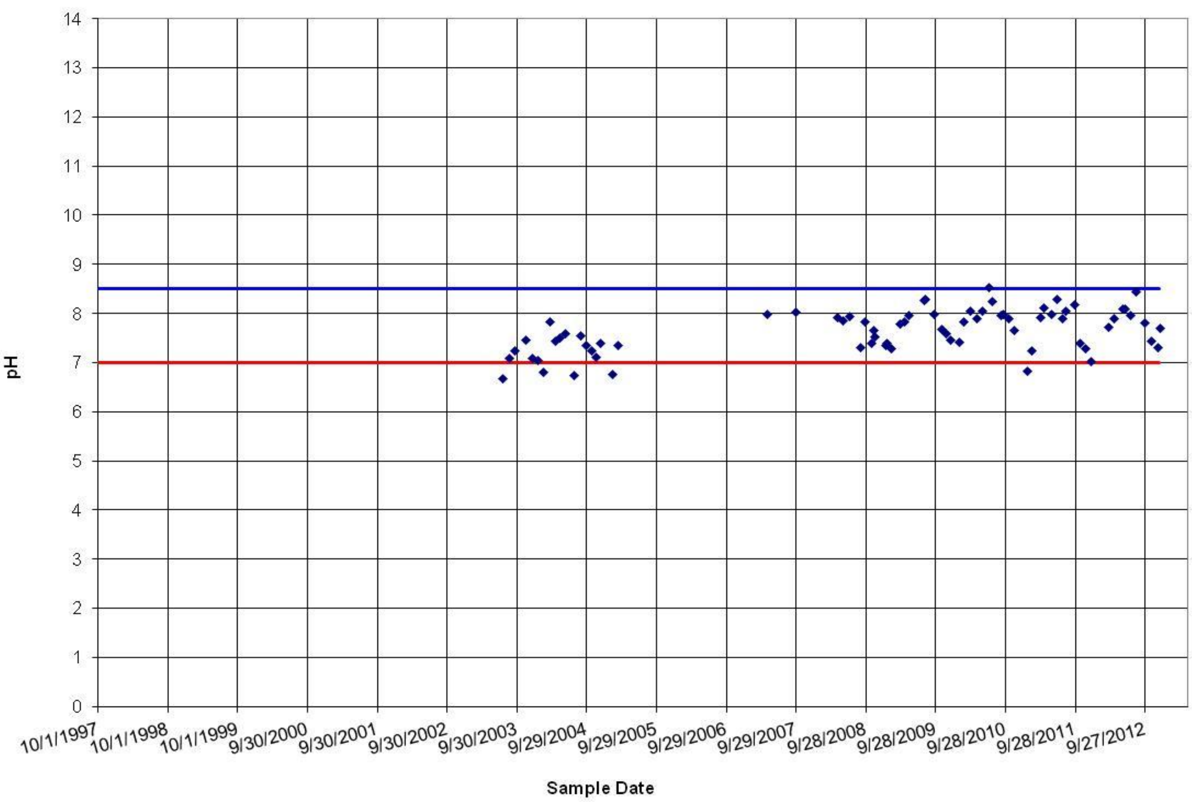

Figure 6.87 Class A Marine Water pH Results, Site SW030

6.10.Turbidity Results

The turbidity water quality standard is expressed as relative to background turbidity levels and is the same for Class AA and Class A waters. To comply with the Lummi Nation water quality standards, the turbidity level shall not exceed 5 nephelometric turbidity units (NTUs) over background turbidity when the background turbidity is less than or equal to 50 NTUs or the turbidity shall not exceed more than 10 percent of the background turbidity when the background turbidity is greater than 50 NTUs. For regulatory purposes (e.g., a construction site) the background turbidity is measured upstream from where storm water from a site discharges to receiving waters and compliance is determined by comparison of this upstream value with the turbidity measurement collected downstream from the point or points that the storm water from the site discharges to the receiving waters.

6.10.1.Nephelometer Results

Turbidity is a measure of the degree to which light is scattered by suspended particulate material and soluble colored compounds in the water. It provides an estimate of the muddiness or cloudiness of the water due to clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. Turbidity is commonly measured with a nephelometer and is reported in nephelometric turbidity units (NTUs). Turbidity is also commonly measured with a Secchi disc. Equipment and staff constraints have previously limited the collection of turbidity data at the surface water quality sample stations. These obstacles were overcome in April 2008 and a nephelometer is now used regularly to determine both background levels and for regulatory compliance with the water quality standards. On the marine boat accessible run and Lummi Bay DOH support run (Table 4.1) a Secchi disc is used to measure water clarity. Secchi depth measurements have not been collected consistently during the period of record, but since 2009 Secchi depth has been measured at all sample sites during monthly marine boat runs. It is recognized that turbidity levels are highly dependent on stream flow and that since stream flow is not commonly measured at most of the sample stations, the comparability of the turbidity data between sites and sampling events is limited. However, the increased measurement of turbidity as part of the ambient water quality program will help establish the background turbidity level for compliance with the water quality standards.

As shown in Figure 6.88, sample Sites SW012 and SW014 were the only Class AA freshwater sample sites that were always below 50 NTUs during 2009 through 2012. The average turbidity was below 50 NTUs at 11 of the 15 sites. During 2009 through 2012, the highest Class AA freshwater turbidity measured was 627 NTUs at Site SW009 (Lummi River at Slater Road) and the lowest turbidity measured was 1 NTU at Sites SW010 and SW011 (along the northern Reservation boundary). As shown in Figure 6.89, during 2009 through 2012, five of the eight Class A sample sites were always below 50 NTUs. All the sample sites have a low number of data values due to low flow or no flow during the summer months.

Turbidity is measured using the nephlometer at marine sample sites in the Lummi River Delta and along the Lummi Peninsula/Portage Bay shoreline. As shown in Figure 6.90, the turbidity at all Class AA marine sample sites were greater than 50 NTUs at least once during 2009 through 2012, except at three of the sites (DH044, DH045 and SW052). However, the average turbidity was below 50 NTUs at all Class AA marine sample sites. Sample Site SW008 (Lummi River at Hillaire Road Bridge) had the highest turbidity recorded of the Class AA Marine sample sites, at 308 NTUs. Site SW008 is downstream from Site SW009 on the Lummi River but is a Class AA marine water site (LWRD 2008a). The maximum turbidity at Site SW008 (308 NTUs) is lower than the maximum value at Site SW009, which at 627 NTUs was the highest turbidity value of all 25 freshwater sites. As shown in Figure 6.91, all Class A marine sample sites had turbidity values exceeding 50 NTUs at least once during 2009 through 2012. Sample Site SW030 (Bellingham Bay) had the highest Class A marine water turbidity recorded, 821 NTUs, and an average turbidity greater than 50 NTUs. As shown in Figure 6.91, the turbidity at the sample sites generally decreased further along the Lummi Peninsula/Portage Bay shoreline moving away from the mouth of the Nooksack River toward Hermosa Beach. These trends suggest that the large quantity of highly turbid water flowing down the Nooksack River impacts turbidity measurements at the Portage Bay sample sites.

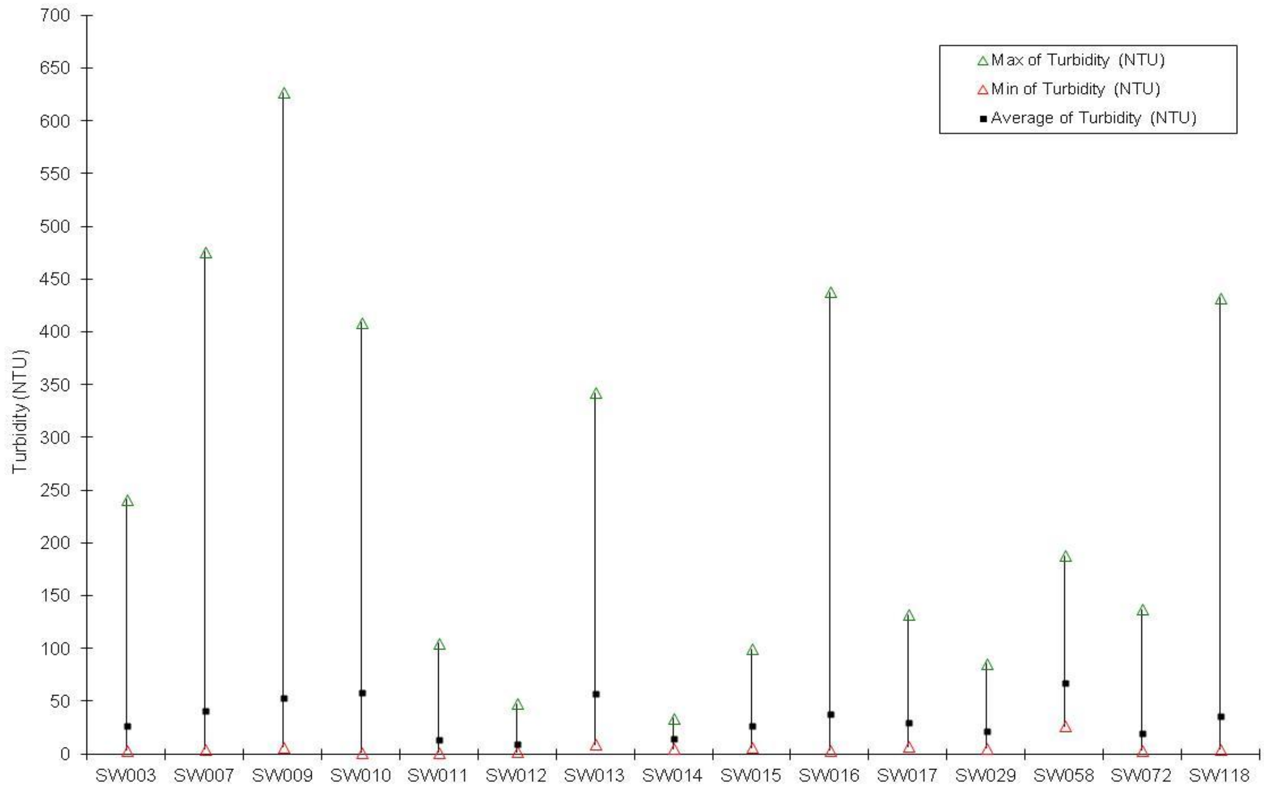

Figure 6.88 Class AA Freshwater Turbidity Results (NTU): 2009 - 2012

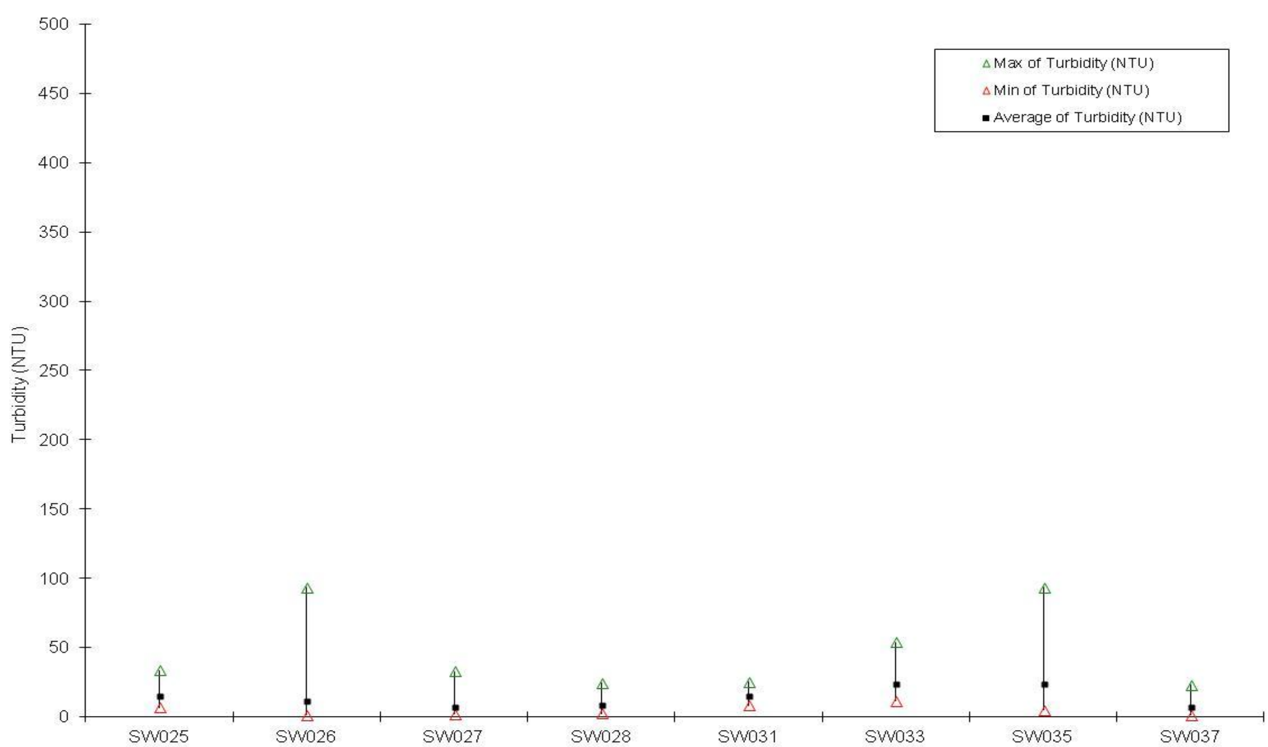

Figure 6.89 Class A Freshwater Turbidity Results (NTU): 2009 - 2012

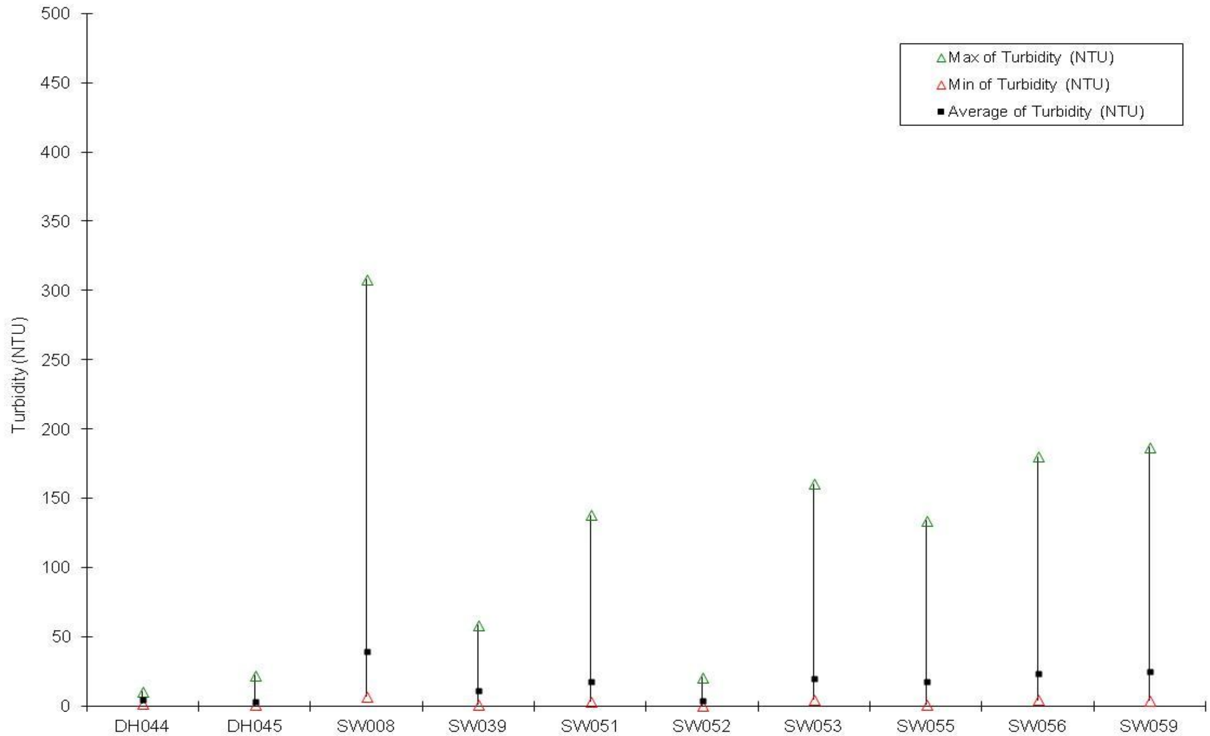

Figure 6.90 Class AA Marine Water Turbidity Results (NTU): 2009 - 2012

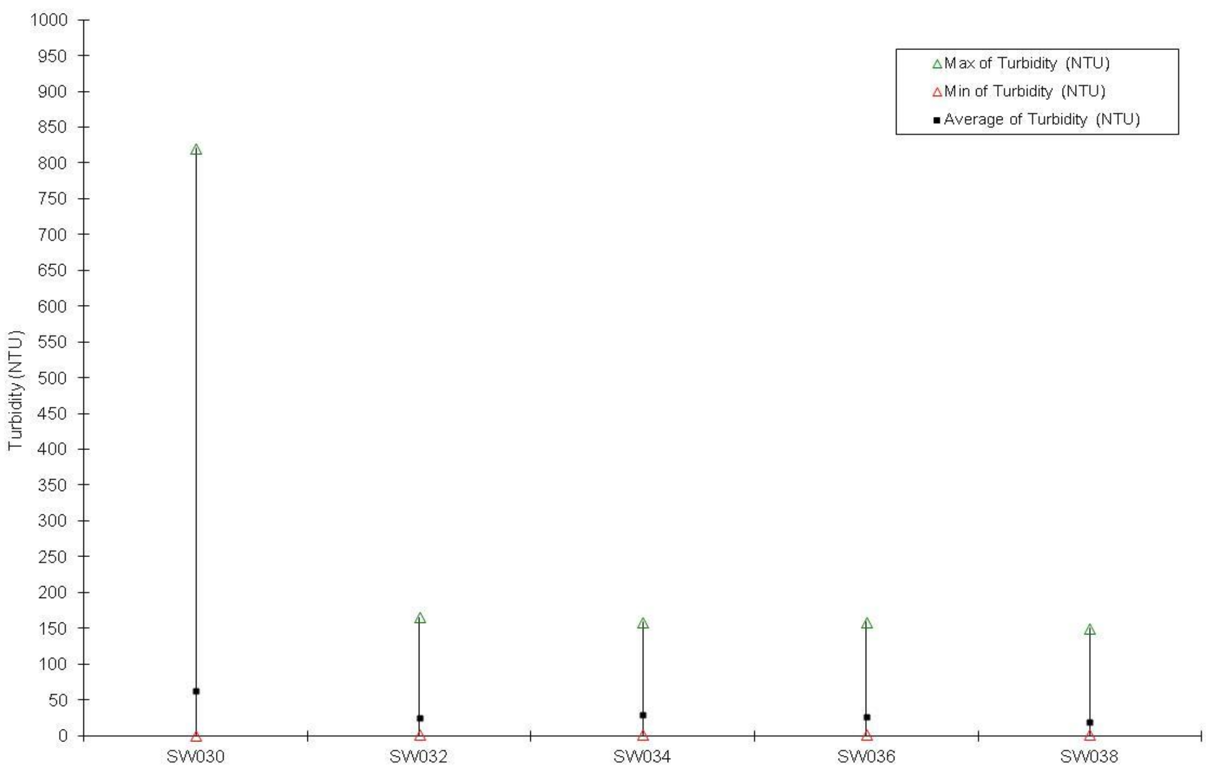

Figure 6.91 Class A Marine Water Turbidity Results (NTU): 2009 - 2012

6.10.2. Total Suspended Solid Results

Total suspended solids (TSS) are very closely associated with turbidity and are expressed in milligrams per liter (mg/l). Total suspended solids have been measured at five reference stations on a quarterly basis. The five reference stations and associated water quality classifications are the following:

- Site SW002 - Class AA Marine Water
- Site SW003 - Class AA Freshwater
- Site SW006 - Class A Marine Water
- Site SW009 - Class AA Freshwater
- Site SW015 - Class AA Freshwater

During 2012, a TSS sample was taken each quarter at three of the five reference stations, three times at Site SW015, and two times at Site SW009, due to no flow being present during the third quarter at SW015 and no flow being present during the third and fourth quarters at SW009. As all of the Class A freshwater sites on the Reservation are small intermittent streams, the limited availability of flow at these Class A freshwater sites makes monthly sampling for the nutrient suite (including TSS) impractical due to schedule and cost considerations.

As shown in Figure 6.92 the quarterly TSS measurements at only 1 of the 5 sample sites was below 50 mg/l during the period of record through 2012 with the lowest TSS levels measured at Site SW006 (Portage Bay). The highest TSS levels were measured at Site SW009 (Lummi River at Slater Road) for the period of record through 2012. Two measurements at this station were collected on August 23, 2001 during a period when the Nooksack River was discharging to the Lummi River channel (which occurs when the flow in the Nooksack River is above approximately 9,600 cfs). A third high TSS measurement was collected November 7, 2008 following several days of significant rainfall. Figure 6.93 shows the TSS measurements over the period of record through 2012 at the three Class AA surface water sites in the Lummi Bay watershed. As shown in Figure 6.93 although a TSS measurement greater than 50 mg/l was recorded at all three sites, with one measurement at SW009 above 50 mg/l occurring in 2012, in general the TSS measurements at these sites are less than 50 mg/l.

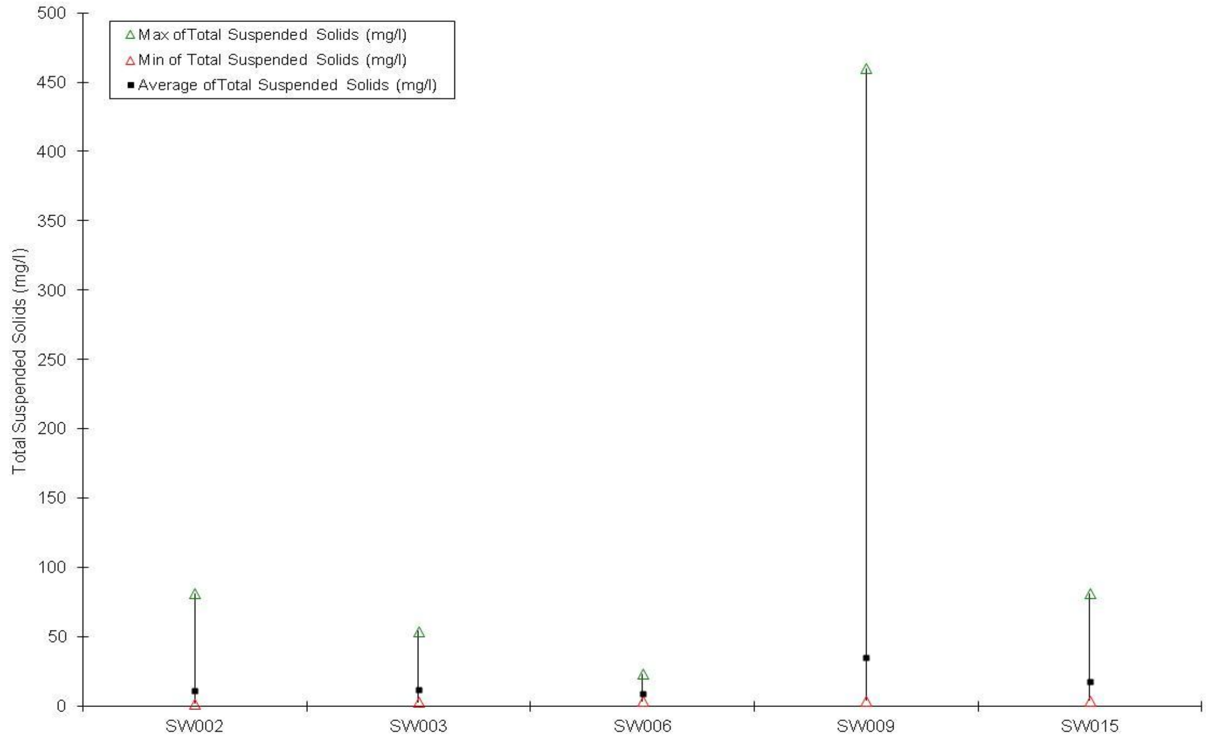

Figure 6.92 Total Suspended Solids Results: Period of Record through 2012

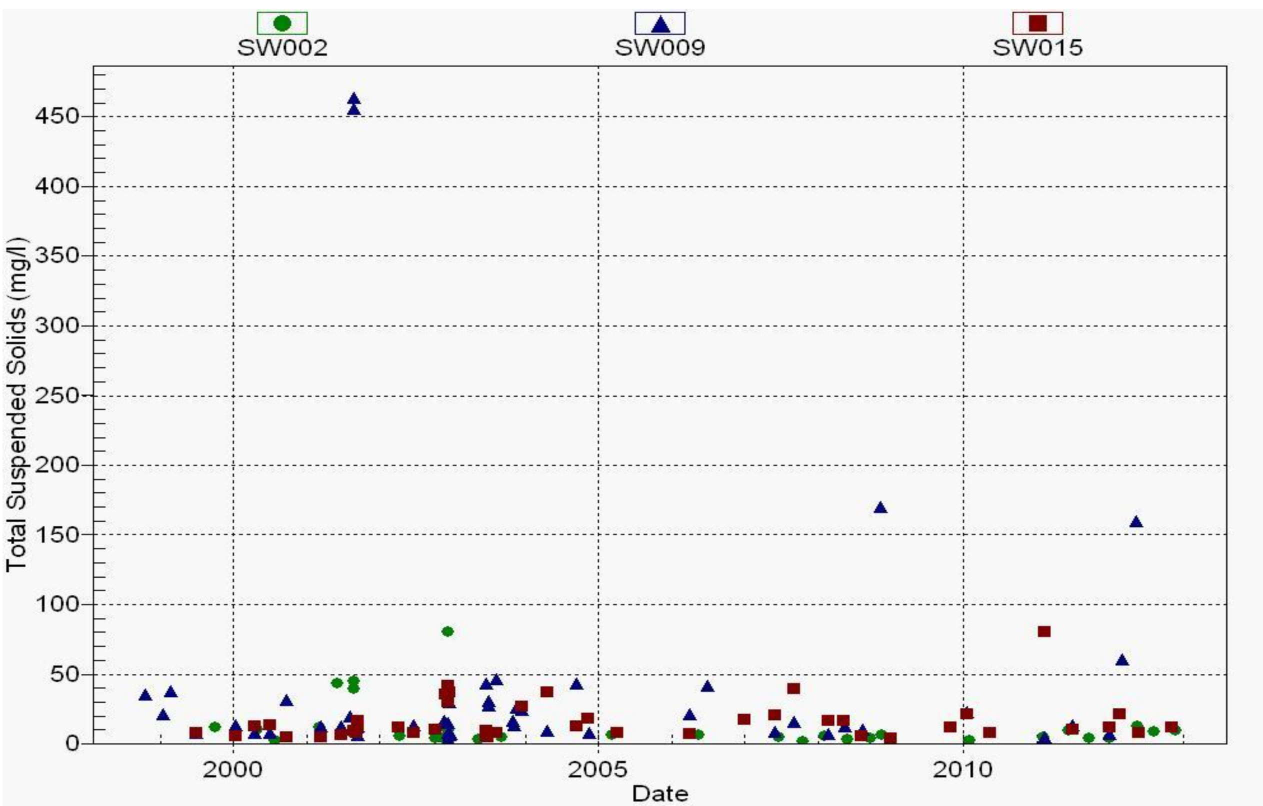

Figure 6.93 Total Suspended Solids Results at Class AA Surface Water Sites: Period of Record through 2012

6.11. Nutrients Results

A nutrient suite, including total phosphorus (milligrams per liter) and total nitrogen (milligrams per liter), is measured quarterly at the same five reference sites where TSS is measured. Similar to TSS the limited availability of flow during the third and fourth quarter of 2012 reduced the number of nutrient samples collected at two of the five sites. Phosphorus and nitrogen are essential nutrients for plant growth. However, elevated phosphorus and nitrogen levels can result in algae blooms, which can interfere with other aquatic life forms (Hem 1989) and can cause a number of environmental and health problems including:

- Aesthetic degradation – water with large algae blooms is murky, has bad odor, and is generally undesirable for water contact recreation such as swimming, wading, fishing, and boating.
- Aquatic habitat degradation – algae can result in low oxygen levels in the water when the algae decay, which can result in winter and summer fish kills.
- Toxin production – certain species of blue-green algae can produce toxins that can affect people and animals that swim and drink from water with severe algae blooms.
- Drinking water degradation – excessive algae in drinking water supplies can affect the taste and odor of drinking water and increase treatment costs.
- Disrupt fish harvests – excess algae can clog fishing nets.

6.11.1. Total Phosphorus Results

During 2012, a total phosphorus sample was taken each quarter at three of the five reference stations, three times at Site SW015, and two times at Site SW009 due to no flow being present during the third quarter at SW015 and no flow being present during the third and fourth quarters at SW009. As shown in Figure 6.94 and Figure 6.95, Site SW009 had the highest total phosphorus values measured over the period of record through 2012, and the two marine water sites (SW002 and SW006) had the lowest total phosphorus values over the period of record. The two other freshwater sample sites in the floodplain (SW003 and SW015) had similar ranges and average total phosphorus levels.

Phosphorus is highly immobile and needs to be attached to a surface for transportation. Soil is frequently a point of attachment for phosphorus, and when soils are exposed, they are susceptible to erosion and can easily be washed into streams and bays during storm events together with the adhered phosphorus. Large areas of land that have been cleared for agriculture and construction sites and are not configured with proper best management practices can contribute a significant amount of nutrient-containing sediments to nearby water bodies.

As shown in Figure 6.95, although there are a few instances with higher total phosphorus levels in the freshwater sites, particularly along the Lummi River at Slater Road (Site SW009), the total phosphorus measurements are generally below 1 mg/l over the period of record. As reported in Dunne and Leopold (1978), in 1967 a committee of the American Water Works Association (AWWA) published the range of usual concentrations of phosphorus in discharges from various land uses. The usual concentration of phosphorus in rural runoff from agricultural lands is 0.05 to 1.1 mg/l and the usual concentration of phosphorus for rural runoff from non-agricultural lands is 0.04 to 0.2 mg/l. There was insufficient data for the AWWA committee to make an estimate for the usual range of phosphorus concentration where farm animal waste was the source, but the committee estimated a range of 3.5 to 9 mg/l of phosphorus for domestic waste. The concentration of total phosphorus at the freshwater sites indicates that the sources of phosphorus are from agricultural land, which is prevalent in off-Reservation watersheds.

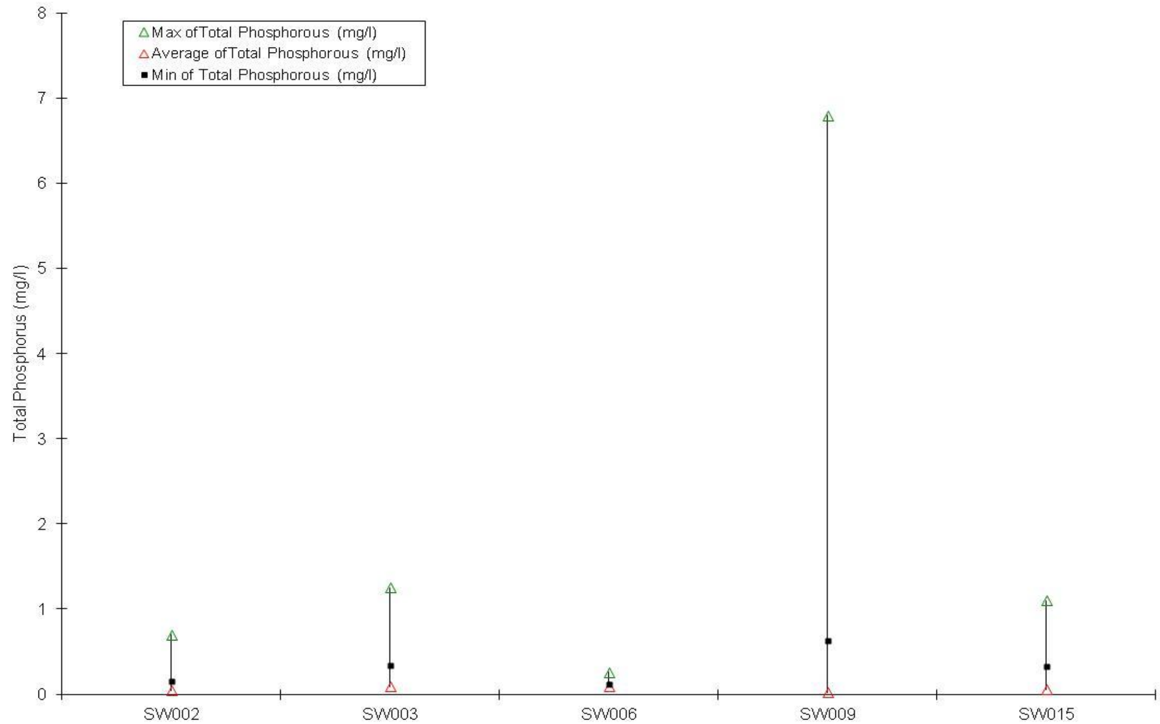

Figure 6.94 Total Phosphorus Results: Period of Record through 2012

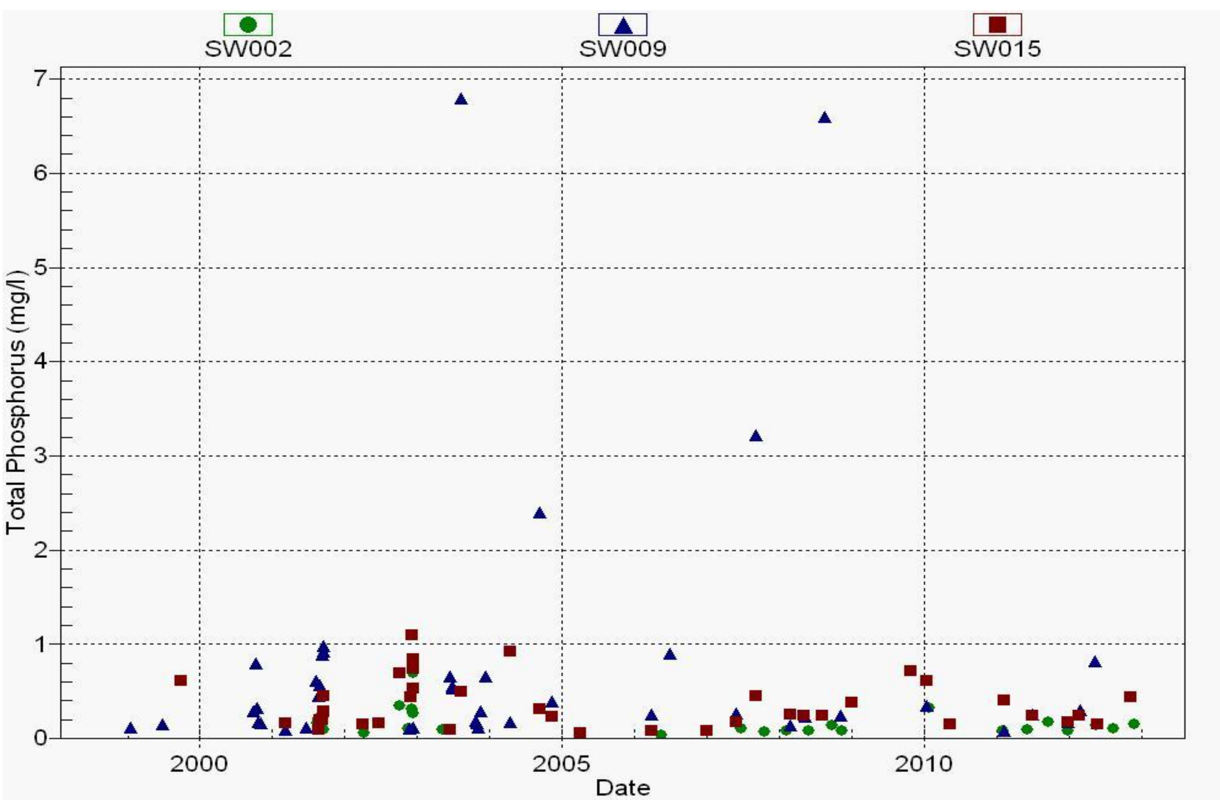

Figure 6.95 Total Phosphorus Results at Class AA Surface Water Sites: Period of Record through 2012

6.11.2. Total Nitrogen Results

Total nitrogen (milligrams per liter) is the sum of the various forms of nitrogen (nitrite, nitrate, and Total Kjeldahl Nitrogen). In the water quality samples collected on the Reservation, the form of nitrogen with the largest concentration was typically Total Kjeldahl Nitrogen (TKN), which is the sum of ammonia (NH_3) and organic nitrogen. As described above, during 2012 total nitrogen was collected four times at three of the five sites and three or two times for the remaining two sites. As shown in Figure 6.96, similar to TSS and total phosphorous, the highest total nitrogen values measured over the period of record through 2012 were at Site SW009 (Lummi River at Slater Road), and the lowest levels measured were at the marine water sites in Lummi Bay (SW002) and Portage Bay (SW006).

As shown in Figure 6.97, the Total Kjeldahl Nitrogen levels in the freshwater sites are all less than 10 mg/l. As reported in Dunne and Leopold (1978), in 1967 a committee of the American Water Works Association (AWWA) published the range of usual concentrations of nitrogen in discharges from various land uses. The usual concentration of nitrogen in rural runoff from agricultural lands is 1 to 70 mg/l and the usual concentration of nitrogen for rural runoff from non-agricultural lands is 0.1 to 0.5 mg/l. There was insufficient data for the AWWA committee to make an estimate for the usual range of nitrogen concentration where farm animal waste was the source, but the committee estimated a range of 18 to 20 mg/l of nitrogen for domestic waste. Based on the concentrations from the AWWA committee, the high levels of total nitrogen at Site SW009 indicate that dairy waste spills or manure applications during the wet season could be the source of excess nitrogen.

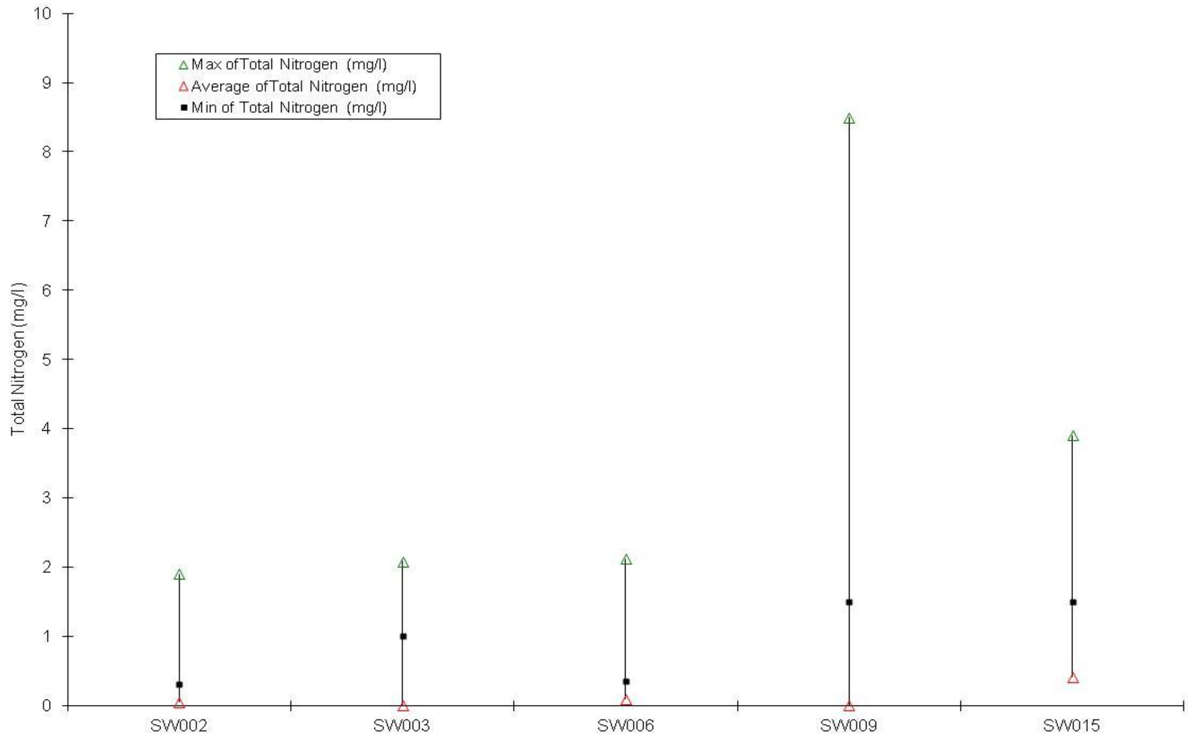

Figure 6.96 Total Nitrogen Results: Period of Record through 2012

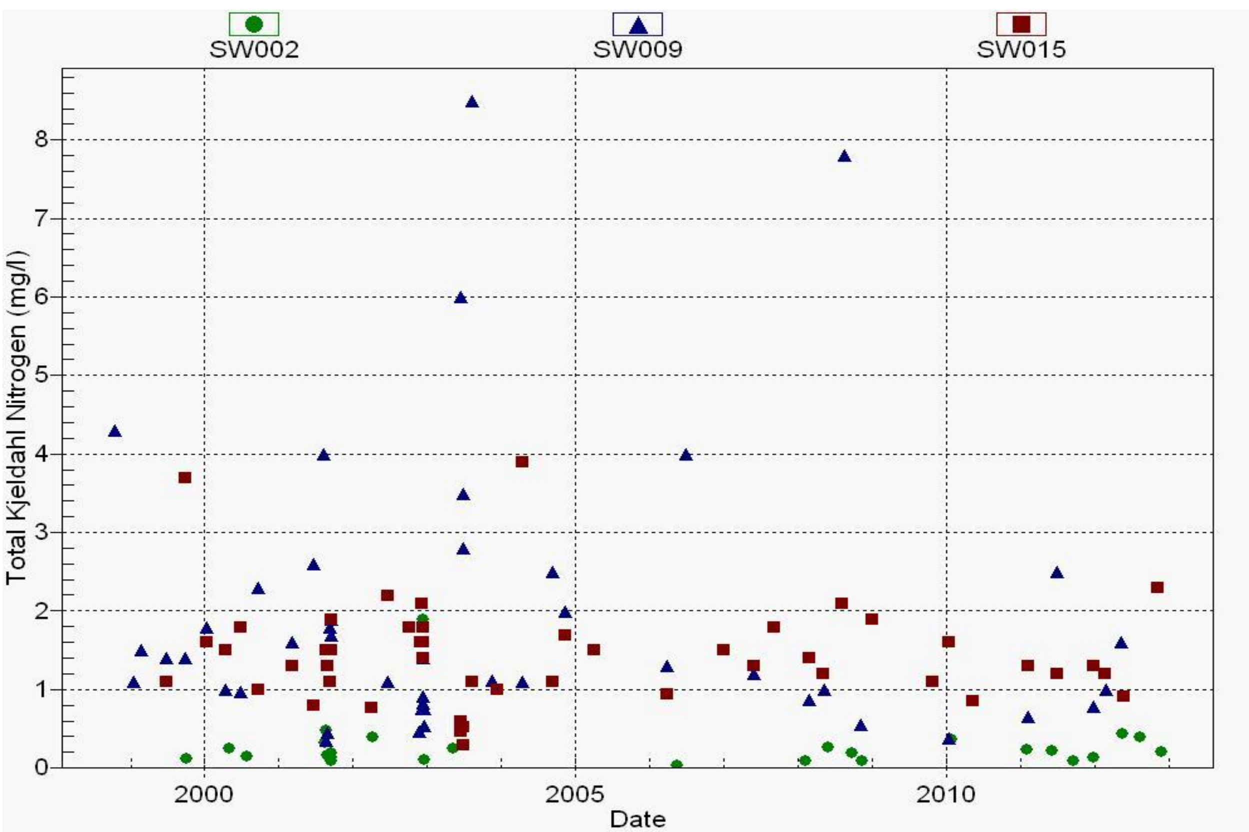

Figure 6.97 TKN Results at Class AA Surface Water Sites: Period of Record through 2012

7. DISCUSSION

Reservation water quality remains complex due to the interaction of marine waters and freshwater, variable tidal conditions during sampling, and seasonal weather patterns. During the summer, upland sites can dry out or become saline, and are often heated due to solar radiation. Once the wet season starts, flow begins at the sites that dried out, and the water column becomes less saline. During the wet season, the waters tend to have dense populations of bacteria and low concentrations of dissolved oxygen (bacteria consume oxygen, which contribute to the lower dissolved oxygen levels). The cycle starts again at the beginning of the next dry season.

The water quality parameters at most of the sites during 2012 followed the trends of the 2003 to 2011 period: a recurrence of elevated bacteria levels, elevated temperatures, and low dissolved oxygen levels compared to the improvements in these parameters observed during 2000 and 2001. As shown in Table 7.1 and Table 7.2, the water quality at many sites during 2012 did not meet one or more of the water quality standards. None of the sample sites in the Lummi Bay Watershed achieved all of the water quality standards during 2012.

The mainstem of the Nooksack River at Marine Drive (SW118) showed an increase in bacteria levels during 2012 compared to levels observed during the 2003 through 2011 period. The Nooksack River did not meet the 90th percentile fecal coliform water quality standard or the TMDL standard established for the river. Accordingly, sample sites in Portage Bay (SW032, SW034, SW036, and SW038) showed a decrease in water quality compared with 2011 as none of the sites met the Class A marine water quality standards for fecal coliform bacteria during 2012. Overall, a continuing trend observed in both the Bellingham and Lummi Bay watersheds was the introduction of fecal contamination into these bays from rivers, ditches, and streams originating off the Reservation. There are water quality and water quantity challenges in the Nooksack and Lummi River watersheds due to off-Reservation land development and agriculture. The primary data relationships used to form these conclusions were the elevated fecal coliform bacteria levels at freshwater sites and also marine sites in close proximity to large freshwater sources.

Dilution and deactivation from the saline waters in the bays decreased the bacteria densities from the levels found in the freshwater sample sites, but not enough to consistently avoid exceeding water quality criteria protective of shellfish harvesting. Figure 7.1 and Figure 7.2 show how the geometric mean of the fecal coliform bacteria density generally decreases moving downstream in the Lummi River and Jordan Creek watersheds over the period of record through 2012. Both of these water bodies discharge to Lummi Bay. Site SW009 shown in Figure 7.1 is located in the Lummi River channel at the northern boundary of the Reservation, Site SW008 is located where the Lummi River channel flows under the Hillaire Road Bridge, Site SW051 is located where the Lummi River discharges to Lummi Bay, and sites DH288, DH040, and SW002 are located in Lummi Bay (see Figure 4.1). The geometric mean decreases along the Lummi River from 214 cfu/100 ml at the Reservation boundary (SW009) to 11 cfu/100 ml at the mouth of the Lummi River (SW051). Sites SW010 and SW011 shown in Figure 7.2 are located along the northern Reservation boundary and contribute to Site SW003, which is located just upstream from where the channel flows under North Red River Road. Site SW053 is located just downstream from the tide gates at Lummi Bay at the mouth of Jordan Creek, and sites DH286 and DH287 are located in Lummi Bay. The geometric mean decreases along Jordan Creek from 82 cfu/100 ml and 154 cfu/100ml at the Reservation boundary (SW010 and SW011 respectively) to 29 cfu/100 ml at the mouth of Jordan Creek (SW053), and to 5 cfu/100 ml and 3 cfu/100 ml in Lummi Bay (DH286 and DH287 respectively).

Figure 7.3 and Figure 7.4 show how the 90th percentile of the fecal coliform bacteria density decreases moving downstream in the Lummi River and Jordan Creek watersheds over the period of record through 2012. The 90th percentile decreases along the Lummi River from 2,300 cfu/100 ml at the Reservation boundary (SW009) to 79 cfu/100 ml at the mouth of the Lummi River (SW051). The 90th percentile decreases along the Jordan Creek from 2,400 cfu/100 ml and 1,200 cfu/100 ml at the Reservation boundary (SW010 and SW011 respectively) to 184 cfu/100 ml at the mouth of Jordan Creek (SW053), to 33 cfu/100 ml and 8 cfu/100 ml in Lummi Bay (DH286 and DH287 respectively).

Figure 7.5 shows how the geometric mean of the fecal coliform bacteria density generally decreases moving from the Nooksack River main channel south into Portage/Bellingham Bay. The geometric mean decreases in the Nooksack River from 31 cfu/100 ml at the Reservation boundary (SW118) to 5 cfu/100 ml at the southeastern most DOH site in Portage Bay (DH049). Figure 7.6 depicts a similar decreasing trend for the 90th percentile of fecal coliform bacteria at the same sites in the Bellingham Bay watershed. The 90th percentile decreases from 112 cfu/100 ml in the Nooksack River at the Reservation boundary (SW118) to 49 cfu/100 ml at the southeastern most DOH site in Portage Bay (DH049).

Overall, when comparing fecal coliform densities in the two major watersheds on the Reservation (Lummi Bay and Portage Bay), water quality sites in the Lummi Bay watershed have a higher geometric mean and 90th percentile than sites in the Portage Bay watershed. In Figure 7.1 and Figure 7.2, which depict changes in fecal coliform bacteria geometric mean moving downstream in the Lummi Bay watershed, the y-axis (fecal coliform bacteria densities) ranges from 3 – 214 cfu/100 ml. In comparison, Figure 7.5 shows Portage Bay watershed fecal coliform geometric means ranging between 5 – 31 cfu/100 ml. Similar results are observed in the 90th percentile calculations for fecal coliform bacteria. The 90th percentile of sample sites in the Lummi Bay watershed range between 8 – 2,300 cfu/100 ml; sample sites in the Portage Bay watershed range from 49 – 112 cfu/100 ml. The poor water quality in the Lummi Bay watershed is a major concern due to the potential for new closures of important tribal shellfish beds.

Table 7.1 Extent Lummi Bay Meets Lummi Water Quality Standards and Designated Uses Supported During 2012

	Location	Fecal Coliform Bacteria (cfu/100ml)	Enterococcus (cfu/100ml)	Temperature (^{o}C)	Dissolved Oxygen (mg/L)	pH	Full Support
LUMMI BAY WATERSHED	**Jordan Creek**						NO
	SW010	X	X	X	X	•	
	SW011	X	X	•	X	•	
	SW003	X	X	X	X	X	
	SW053	X	X	X	X	X	
	Lummi River						NO
	SW009	X	X	•	X	X	
	SW008	X	X	X	X	X	
	SW013	X	X	X	X	•	
	SW051	X	X	X	X	X	
	SW055	X	X	X	X	X	
	Smuggler's Slough						NO
	SW072	X	X	X	X	X	
	SW015	X	X	X	X	X	
	SW059	X	X	X	X	X	
	SW056	X	X	X	X	•	
	Schell Creek						NO
	SW012	•	•	X	X	X	
	Onion Creek						NO
	SW014	•	X	X	X	X	
	Seapond Creek						NO
	SW029	X	X	•	X	X	
	East Reservation Boundary						NO
	SW016	X	X	•	X	•	
	SW017	•	X	X	X	•	
	Sandy Point Channel						NO
	SW001	•	•	X	•	•	
	SW019	•	•	X	X	X	
	Lummi Bay						NO
	SW002	•	•	X	•	X	
	SW022	•	•	X	•	X	
	SW052	•	•	X	•	•	
	DH038	•	**N/A**	X	•	•	
	DH039	•	**N/A**	•	•	•	
	DH040	•	**N/A**	•	•	•	
	DH041	•	**N/A**	X	•	X	
	DH042	•	**N/A**	X	•	X	
	DH043	•	**N/A**	X	•	•	
	DH044	•	**N/A**	X	•	•	
	DH045	•	**N/A**	X	•	X	
	DH285	•	**N/A**	X	•	•	
	DH286	•	**N/A**	X	•	X	
	DH287	•	**N/A**	•	•	•	
	DH288	•	**N/A**	X	•	•	

X = standard not achieved; • = standard achieved; **N/A** = Not determined

Table 7.2 Extent Bellingham Bay Meets Lummi Water Quality Standards and Designated Uses Supported During 2012

	Location	Fecal Coliform Bacteria (cfu/100ml)	Enterococcus (cfu/100ml)	Temperature (^{o}C)	Dissolved Oxygen (mg/L)	pH	Full Support
BELLINGHAM BAY WATERSHED	**Nooksack River**						**NO**
	SW118	**X**	**X**	**X**	**X**	**X**	
	Kwina Slough						**NO**
	SW007	**X**	**X**	•	**X**	**X**	
	Lummi Shore Road Watershed						**NO**
	SW031	•	•	•	**X**	**X**	
	SW032	**X**	**X**	**X**	•	**X**	
	SW033	•	•	•	**X**	**X**	
	SW034	**X**	**X**	**X**	•	**X**	
	SW035	•	•	•	**X**	**X**	
	SW036	**X**	**X**	**X**	•	•	
	SW037	•	•	•	•	**NA**	
	SW038	**X**	**X**	**X**	•	•	
	SW039	**X**	**X**	**X**	**X**	•	
	Portage Island						**NO**
	SW026	•	•	**X**	**X**	•	
	SW027	**X**	**X**	•	**X**	•	
	SW028	•	•	**X**	•	**X**	
	Portage Bay						**NO**
	SW006	•	•	**X**	•	**X**	
	SW023	•	•	**X**	•	•	
	SW030	**X**	**X**	**X**	•	•	
	DH049	**X**	**N/A**	**X**	**N/A**	**N/A**	
	DH050	•	**N/A**	**X**	**N/A**	**N/A**	
	DH051	•	**N/A**	**X**	**N/A**	**N/A**	
	DH052	**X**	**N/A**	**X**	**N/A**	**N/A**	
	DH053	•	**N/A**	**X**	**N/A**	**N/A**	
	DH054	•	**N/A**	**X**	**N/A**	**N/A**	
	DH055	•	**N/A**	**X**	**N/A**	**N/A**	
	DH057	•	**N/A**	**X**	**N/A**	**N/A**	
	DH058	**X**	**N/A**	**X**	**N/A**	**N/A**	
	DH271	**X**	**N/A**	**X**	**N/A**	**N/A**	
	DH272	•	**N/A**	**X**	**N/A**	**N/A**	

X = standard not achieved; • = standard achieved; N/A = Not determined

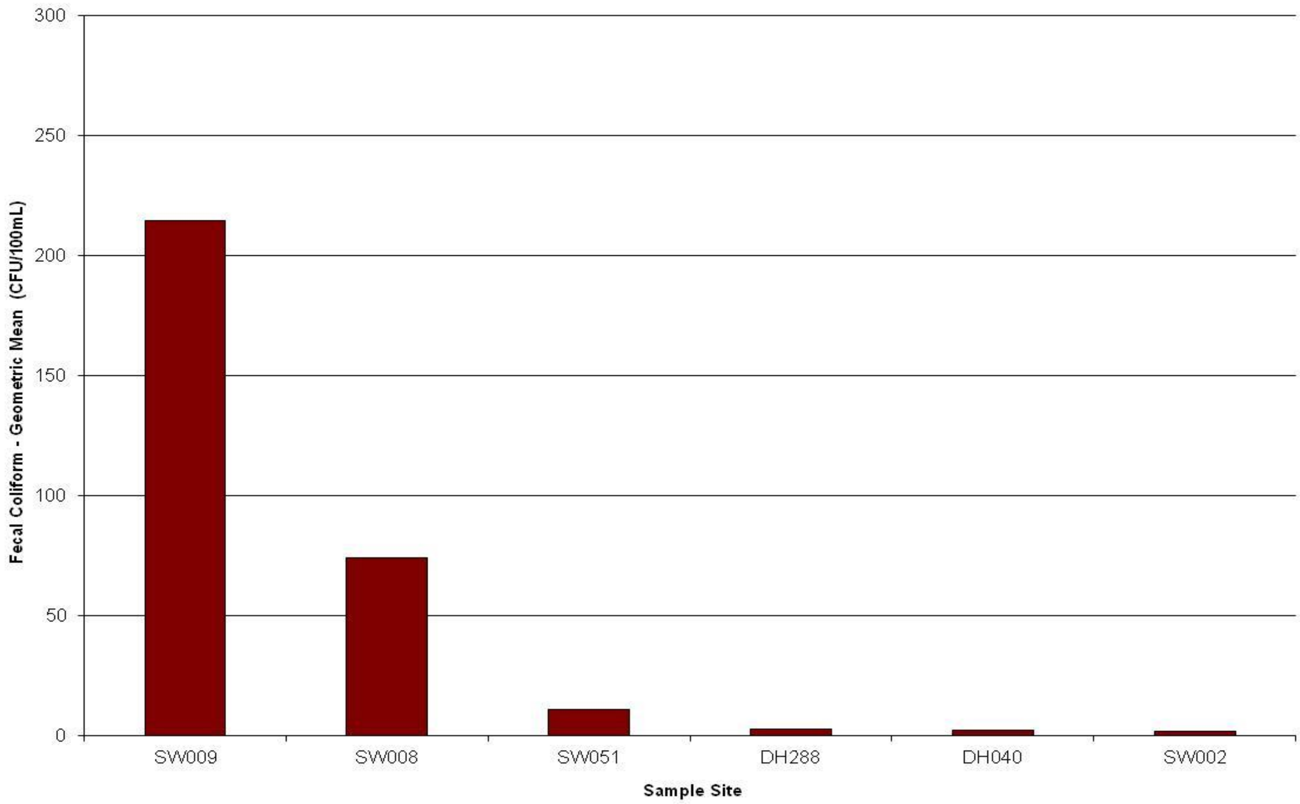

Figure 7.1 Changes in the Geometric Mean of Fecal Coliform Bacteria Sample Results in the Lummi River and Lummi Bay: Period of Record through 2012

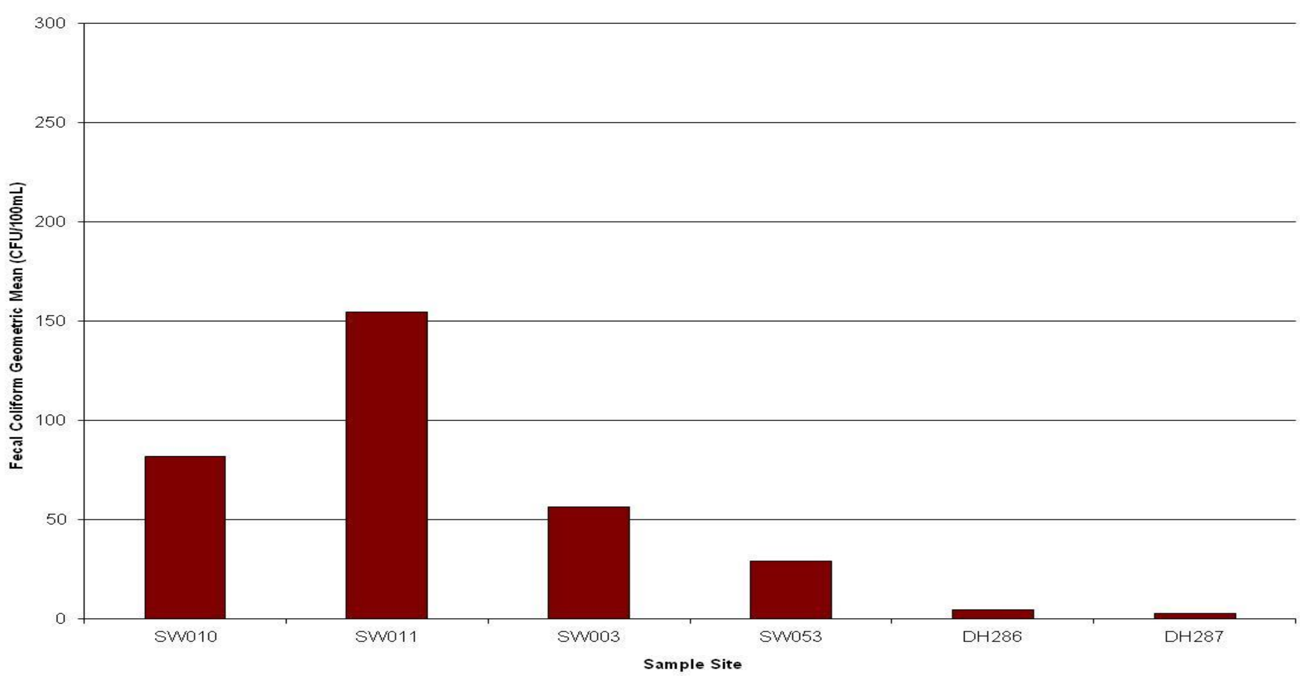

Figure 7.2 Changes in the Geometric Mean of Fecal Coliform Bacteria Sample Results in the Jordan Creek/Lummi Bay Watershed: Period of Record through 2012

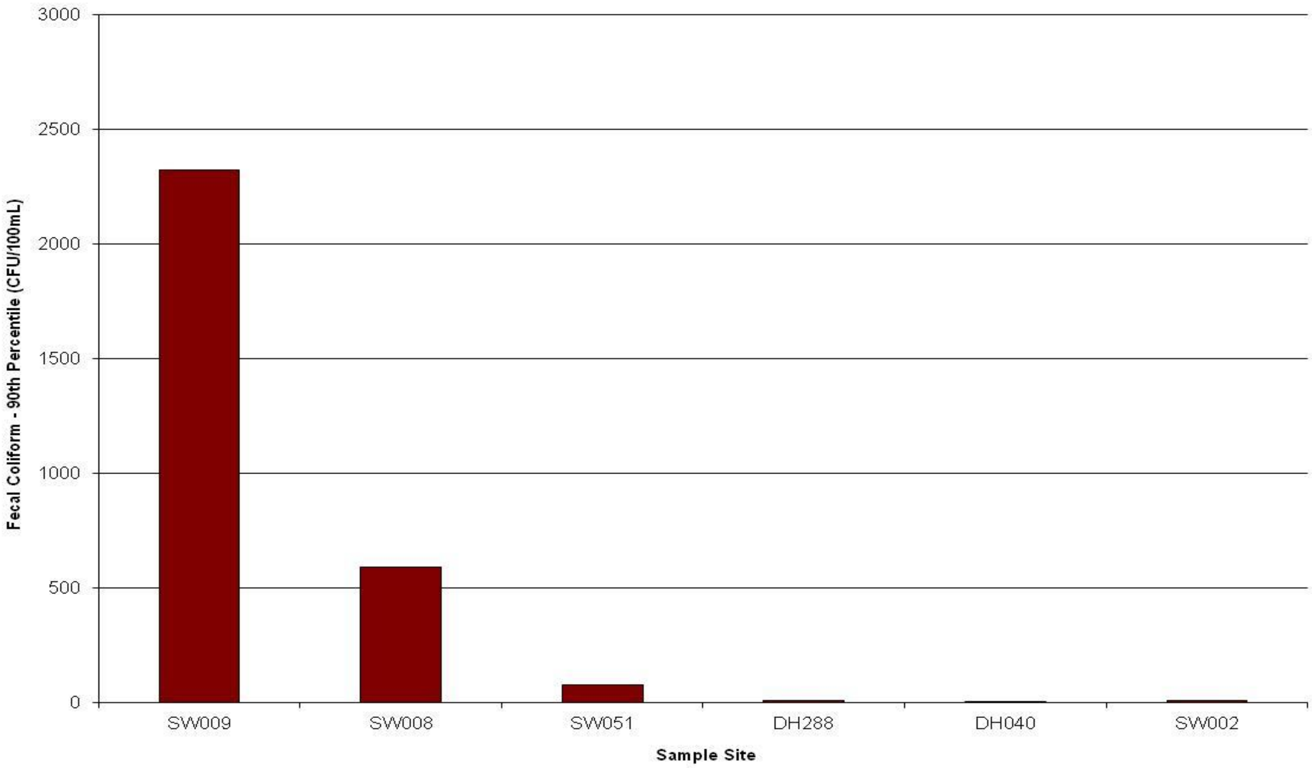

Figure 7.3 Changes in the 90th Percentile of Fecal Coliform Bacteria Sample Results in the Lummi River and Lummi Bay: Period of Record through 2012

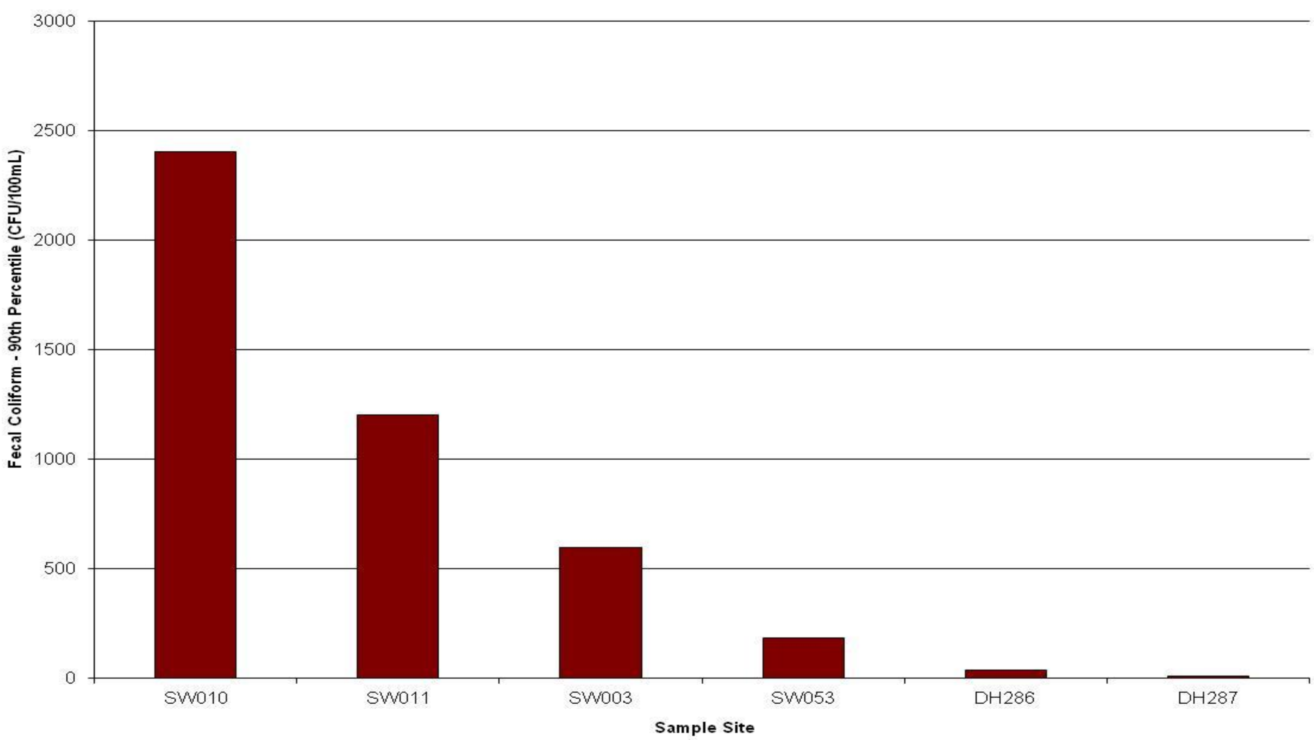

Figure 7.4 Changes in the 90th Percentile of Fecal Coliform Bacteria Sample Results in the Jordan Creek/Lummi Bay Watershed: Period of Record through 2012

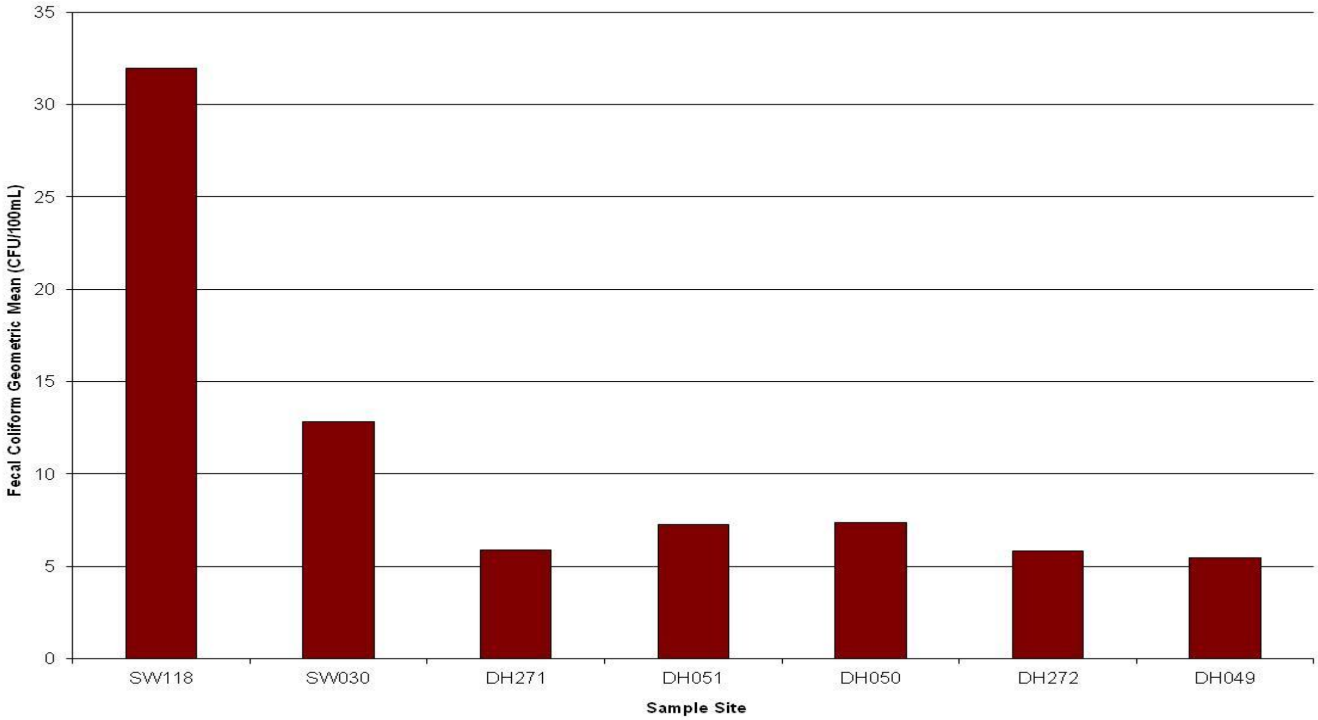

Figure 7.5 Changes in the Geometric Mean of Fecal Coliform Bacteria Sample Results in the Nooksack River/Bellingham Watershed: Period of Record through 2012

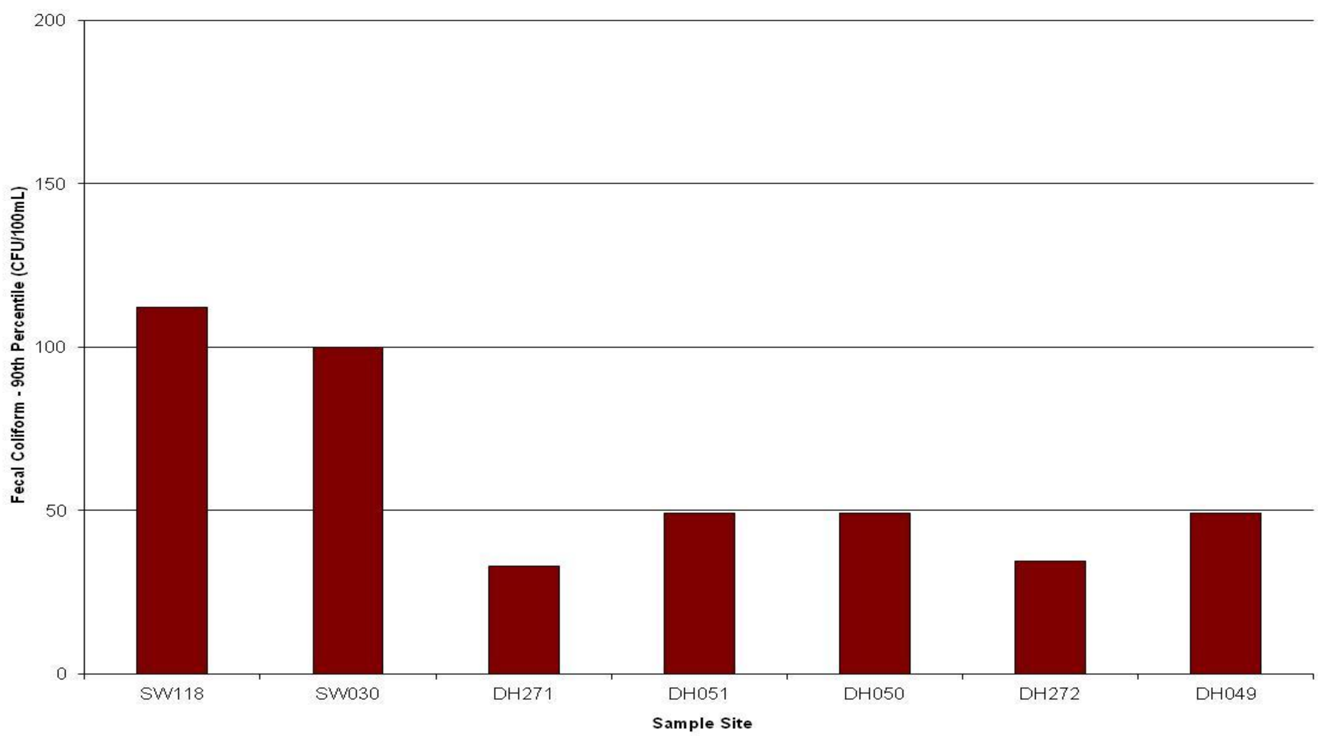

Figure 7.6 Changes in the 90th Percentile of Fecal Coliform Bacteria Sample Results in the Nooksack River/Bellingham Bay Watershed: Period of Record through 2012

7.1. Causes and Sources of Lummi Waters Not Supporting Designated Uses

None of the waters in the Lummi Bay watershed and the Portage Bay watershed support their designated uses because of increased fecal coliform densities, increased temperatures, low dissolved oxygen levels, and/or pH levels (Table 7.1 and Table 7.2). In the Lummi Bay watershed, temperature, pH, and fecal coliform were the most common reason that designated uses are not supported. The primary source of these impairments in the Lummi Bay watershed is off-Reservation agricultural practices. In the Portage Bay watershed, temperature, fecal coliform bacteria, and enterococcous bacteria were the most common causes of waters not supporting their designated use. Again, off-Reservation agricultural land use is the major source of high fecal coliform densities, particularly the Nooksack River watershed, which drains the majority of the agricultural lands in lower Whatcom County.

Fecal coliform bacteria are of particular importance because they are the indicator organism used in the National Shellfish Sanitation Program (NSSP) to classify shellfish beds as suitable for commercial harvest. Both the Lummi and Nooksack River watersheds contain land uses that contribute fecal coliform bacteria to surface waters. As shown in Figure 7.1 through Figure 7.4, the highest fecal coliform bacteria levels are measured along the Reservation boundary, indicating an off-Reservation source. All or portions of approximately 220 acres of tribal shellfish beds in Portage Bay were closed to commercial harvest over the November 1996 to May 2006 period due to bacterial contamination attributed to poor dairy nutrient management practices in the Nooksack River (DOH 1997, Ecology 2000).

The decrease in fecal coliform bacteria densities during 2000 and 2001 in both the Nooksack River and Portage Bay was a positive indication that fecal coliform bacteria pollution prevention efforts were succeeding in the Nooksack River watershed. However, fecal coliform bacteria levels rose again in these water bodies during the 2003 to 2008 period. During 2008 through 2010, the mainstem of the Nooksack River (SW118) showed a continual decrease in fecal coliform bacteria levels. During 2011, the Nooksack River met fecal coliform water quality standards where it flowed onto the Reservation, however, the geometric mean increased from 21 cfu/100 ml in 2010 to 23 cfu/100 ml in 2011. During 2012 the Nooksack River again showed an increase in fecal coliform bacteria levels and did not achieve the 90th percentile nor the target TMDL established for the river. Along the Lummi Peninsula nearshore areas of Portage Bay, storm water during the onset of the wet season typically contains elevated fecal coliform bacteria levels, but flows are very low. By the time the flows increase, fecal coliform bacteria levels are substantially reduced. Intensive shoreline sampling over the 1998 through 2001 period demonstrated that local sources of fecal coliform bacteria are not a significant source of fecal contamination to Portage Bay (LWRD 1999, LWRD 2006a, LWRD 2006b). Small freshwater streams on Portage Island contain elevated fecal coliform bacteria levels, but as described above, flows are very low and do not appear to be a significant source of fecal contamination to Portage Bay. A herd of cattle present on the uninhabited Portage Island is thought to be the main source of high fecal coliform bacteria concentrations in the freshwater streams. Removal of the cattle is currently being conducted, which should reduce the fecal coliform bacteria entering Portage Bay from Portage Island.

Land use practices in the Lummi River watershed are likely the primary cause of the elevated bacteria levels, elevated temperatures, and depressed dissolved oxygen values in the surface waters along the Reservation boundary. Fecal coliform bacteria levels well above the Lummi Nation Surface Water Quality Standards were common along the Reservation boundary sample sites in the early and mid-1990s, and had been decreasing during 2001 and 2002. However, during the 2003 through 2012 period, bacteria levels at many sites along the boundary increased again.

Just as the freshwater system influences the marine waters in the bays, the marine waters influence the freshwater system with upstream flows during high tides. This is especially notable in the Lummi Bay watershed where saline waters reached to the northern Reservation boundary.

As shown in Table 7.1 and Table 7.2, the collected data suggest that 13 of 63 sample sites (21%) throughout the Reservation achieved the water temperature standards during 2012. As noted previously, continuous water temperature data are not collected at most sites so a direct compliance assessment for water temperature is not possible at most sites. However, the 2012 results are comparable to results from previous years and reflect decreased conditions relative to 2011 when the temperature standard was achieved at 25 sites. Some of these exceedences are caused by naturally occurring conditions, such as Site SW002 in Lummi Bay, where the tide flat is exposed to full sunlight in the summer. However, at other sites these exceedences are likely due to human-caused factors such as the removal of riparian vegetation and/or drainage alterations that decrease the amount of groundwater available to moderate surface water temperatures in the summer. The extent to which anthropogenic influences have contributed to elevated water temperatures at the various sample sites has not been established.

Dissolved oxygen levels also vary considerably throughout the year, and not always inversely to temperature. As shown in Table 7.1 and Table 7.2, the majority of water bodies do not achieve the dissolved oxygen (mg/l) water quality standards except Portage Bay and Lummi Bay. At some sites, the deviation of dissolved oxygen and temperature from their expected pattern appears to be due to elevated primary production of oxygen by algae that increases the dissolved oxygen levels concurrent with elevated temperatures. The dissolved oxygen values could range from low to high to low again over a 24-hour period. To explore this phenomenon further, water quality should be sampled several times a day over the course of several days at representative sites.

Other causes of high dissolved oxygen levels concurring with elevated water temperatures may be due to wave entrainment of air or the water heating more rapidly than the rate at which dissolved oxygen maintains equilibrium concentrations in water. In places such as Lummi Bay, air entrainment, primary production, and rapid heating are likely occurring and contributing to elevated dissolved oxygen values. In many places on the Reservation, dissolved oxygen values fall below applicable water quality criteria. Similar to temperature, there are places where extremely low dissolved oxygen values could be due to naturally occurring conditions (e.g., an area without shade where the streambed is in the photic zone and flows are generally low to stagnant). At sites where human created or induced changes occurred (e.g., clearing of vegetation, drainage of groundwater, increased nutrient loading), the extremes of dissolved oxygen variation have likely been increased due to the human activity setting the stage for increased primary production. Similarly, high bacteria densities, often created by anthropogenic activities, can cause decreased dissolved oxygen concentrations as the bacteria consume oxygen during metabolism. The extent to which anthropogenic influences have contributed to depressed dissolved oxygen levels at the various sample sites has not been estimated.

8. SUMMARY AND CONCLUSIONS

The goals of the Lummi Nation Surface Water Quality Monitoring Program are to document ambient water quality and water quality trends on the Lummi Indian Reservation (Reservation), evaluate regulatory compliance of waters flowing through and onto the Reservation including compliance with Lummi Nation Surface Water Quality Standards (LWRD 2008a), and support the development and implementation of water quality regulatory programs on the Reservation.

This report presents the surface water quality data collected during calendar year 2012, compares the 2012 results to data from 1993 to 2011, presents interpretations of these data with respect to the Program goals, and provides the U.S. Environmental Protection Agency (EPA) documentation required pursuant to the *Final Guidance of Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act* (EPA 2006).

Water quality on the Reservation is complex for a number of reasons including the Reservation location in the estuaries of the Lummi River and the Nooksack River where marine and fresh waters interact, the approximately 38 miles of marine shoreline and 7,000 acres of tidelands, and the weather patterns that influence the water quality at the sampling sites.

The water quality parameters measured during calendar year 2012 were largely similar to the measured water quality parameters during previous years with a few notable exceptions. The water quality parameters at the monitoring sites during 2012 generally followed the trends of the time period 2003 to 2011. That is, generally elevated bacteria levels, higher temperatures, and lower dissolved oxygen levels compared to the Lummi Nation Water Quality Standards (LWRD 2008a). Fecal coliform bacteria levels in the mainstem of the Nooksack River at the Reservation border (SW118) increased during 2012 compared to the trends of 2003 through 2011. During 2012, fecal coliform bacteria levels at Site SW118 were higher than the Total Maximum Daily Load (TMDL) target of a geometric mean of 39 coliform forming units/100 ml established for the lower Nooksack River (Ecology 2000 and 2002), and the 90th percentile water quality standard for Class AA freshwater bodies. The water quality parameters are generally more degraded in the sites further inland, and gradually improve downstream towards the marine waters on the Reservation.

The marine waters of Lummi Bay and the Sandy Point Marina continue to have relatively good quality, while the surface waters within the Lummi River watershed continue to have the poorest water quality of the sites sampled on the Reservation. Sampling of the Nooksack River indicated variable water quality with elevated fecal coliform bacteria readings during 2012 that are a cause of concern even though improvements were observed compared to the 2003 through 2007 period. Non-attainment of the fecal coliform water quality standards and TMDL goals in the Nooksack River, where it flows onto the Reservation, and the increasing levels of fecal coliform bacteria in Portage Bay are signs that technical assistance and enforcement actions in the Nooksack River Basin are not enough to adequately protect water quality. The continuing poor water quality in the Lummi River and tributaries to Lummi Bay, particularly with respect to increased fecal coliform bacteria contamination, is a major concern due to the potential for new closures of important tribal shellfish beds. The members of the Lummi Nation use these shellfish beds for ceremonial, subsistence, and commercial purposes.

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10. APPENDIX A - LUMMI NATION SURFACE WATER QUALITY RESULTS: 2012

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Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
2/15/2012	DH038	7.222											
4/11/2012	DH038	10.5											
6/6/2012	DH038	13.278											
8/1/2012	DH038	18.167											
11/26/2012	DH038	10.611											
12/6/2012	DH038	6.556											
2/15/2012	DH039	7.222											
4/11/2012	DH039	49.3											
6/6/2012	DH039	13.167											
8/1/2012	DH039	19.056											
11/26/2012	DH039	11.111											
12/6/2012	DH039	6.778											
2/15/2012	DH040	7.222											
4/11/2012	DH040	49.8											
6/6/2012	DH040	13.611											
8/1/2012	DH040	18.889											
11/26/2012	DH040	10.278											
12/6/2012	DH040	6.361											
2/15/2012	DH041	7.389											
4/11/2012	DH041	10.667											
6/6/2012	DH041	13.056											
8/1/2012	DH041	19.556											
11/26/2012	DH041	9.333											
12/6/2012	DH041	6.389											
2/15/2012	DH042	7.778											
4/11/2012	DH042	11.389											
6/6/2012	DH042	14.389											
8/1/2012	DH042	20.444											
11/26/2012	DH042	10.333											
12/6/2012	DH042	6.222											
2/15/2012	DH043	8.167											
4/11/2012	DH043	11.333											
6/6/2012	DH043	12.444											
8/1/2012	DH043	20.278											
11/26/2012	DH043	10.778											
12/6/2012	DH043	7.333											
2/15/2012	DH044	9											
4/11/2012	DH044	54.1											
8/1/2012	DH044	25.722											
11/26/2012	DH044	6.5											
2/15/2012	DH045	8.139											
4/11/2012	DH045	52											
8/1/2012	DH045	26.111											
11/26/2012	DH045	5.389											

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
12/6/2012	DH045	6.6115											
2/15/2012	DH285	7.056											
4/11/2012	DH285	10.722											
6/6/2012	DH285	11.5											
8/1/2012	DH285	19.667											
11/26/2012	DH285	11.111											
12/6/2012	DH285	5.889											
2/15/2012	DH286	7.389											
4/11/2012	DH286	10.889											
6/6/2012	DH286	10.5											
8/1/2012	DH286	20.667											
11/26/2012	DH286	9.5											
12/6/2012	DH286	6											
2/15/2012	DH287	7.167											
4/11/2012	DH287	10.833											
6/6/2012	DH287	10.833											
8/1/2012	DH287	19.333											
11/26/2012	DH287	10.333											
12/6/2012	DH287	6.167											
2/15/2012	DH288	6.778											
4/11/2012	DH288	11.444											
6/6/2012	DH288	10.278											
8/1/2012	DH288	18.556											
11/26/2012	DH288	9.889											
12/6/2012	DH288	6.278											
1/10/2012	SW001	6										1.9	10
2/1/2012	SW001	8.75										4	9
3/6/2012	SW001	6.389										1.9	9
4/4/2012	SW001	10.167										1.9	10
5/16/2012	SW001	15.111			0.009					0.009	0.07	1.9	9
6/27/2012	SW001	21.944										1.9	9
7/11/2012	SW001	19.611										1.9	1.9
8/9/2012	SW001	22			0.009					0.009	0.045	4	9
9/6/2012	SW001	21.5										6	9
10/9/2012	SW001	12.056										1.9	9
11/27/2012	SW001	8.222			0.009					0.009	0.045	1.9	10
1/10/2012	SW002	8										8	9
2/1/2012	SW002	8.5										2	9
3/6/2012	SW002	7.333										1.9	9
4/4/2012	SW002	10.0835										1.9	9
5/16/2012	SW002	18.833	100	0.045		2	277	5.3				1.9	9
6/27/2012	SW002	18.5555										1.9	9
7/11/2012	SW002	18										1.9	1.9
8/9/2012	SW002	23.278	98	0.05		2.9	150	0.27				2	9

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
9/6/2012	SW002	19.556										1.9	9
10/9/2012	SW002	12.056										2	9
11/27/2012	SW002	8.222	110	0.045		1.6	230	0.27				5	9
1/25/2012	SW003	6										86	64
2/29/2012	SW003	3.611	44	0.17		1.9	33.9	5.3				10	9
3/21/2012	SW003	11.444										30	20
4/23/2012	SW003	17.278										42	10
5/9/2012	SW003	14.333	120	0.045		2	52	17				28	9
6/21/2012	SW003	25.056										32	42
7/18/2012	SW003	17.444										60	60
8/28/2012	SW003	17.111	120	0.05		3.7	150	21				130	560
9/13/2012	SW003	19.444										54	120
10/16/2012	SW003	15.8335										560	75
11/14/2012	SW003	58.6	36	0.13		1.6	45	2				90	150
12/13/2012	SW003	6.222										33	10
5/22/2012	SW004	11.333										460	180
1/10/2012	SW006	9										1.9	9
2/1/2012	SW006	8.5										46	20
3/6/2012	SW006	6.333										24	20
4/4/2012	SW006	11.333										6	10
5/16/2012	SW006	18.333	58	0.045		1.5	93.3	0.27				6	9
6/27/2012	SW006	22.833										2	9
7/11/2012	SW006	22.111										16	16
8/9/2012	SW006	23.5	45	0.045		1.3	40	0.27				12	9
9/6/2012	SW006	21										2	9
10/9/2012	SW006	12.222										1.9	9
11/27/2012	SW006	8.056	70	0.05		1.6	130	2				13	10
1/31/2012	SW007	8.5										80	20
2/7/2012	SW007	10.5										6	9
3/20/2012	SW007	6.5										1.9	9
4/17/2012	SW007	12.444										68	42
5/29/2012	SW007	16										20	9
6/12/2012	SW007	17.944										66	10
7/12/2012	SW007	18.778										26	26
8/8/2012	SW007	20.611										48	75
9/21/2012	SW007	17.056										320	110
10/26/2012	SW007	7.889										140	87
11/28/2012	SW007	7.444										20	9
12/11/2012	SW007	5.6945										38	9
1/25/2012	SW008	7										80	20
2/29/2012	SW008	3.778										42	42
3/21/2012	SW008	9.111										8	10
4/23/2012	SW008	20.278										26	42
5/9/2012	SW008	15.556										200	53

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
6/21/2012	SW008	24.889										240	75
7/18/2012	SW008	18.667										110	110
8/28/2012	SW008	18.1665										30	9
9/13/2012	SW008	20										26	9
10/16/2012	SW008	18.778										2400	1600
11/14/2012	SW008	12.333										110	290
12/13/2012	SW008	6.222										780	150
1/25/2012	SW009	7.25										4	9
2/29/2012	SW009	0.333	220	0.63		40	93.3	1.3				4.9	9
3/21/2012	SW009	10.667										1.9	9
4/23/2012	SW009	19.1945										20	10
5/9/2012	SW009	15.611	280	0.37		12	61.9	110				170	9
6/21/2012	SW009	20.944										160	150
1/25/2012	SW010	5.75										55	20
2/29/2012	SW010	1.111										40	10
3/21/2012	SW010	9.611										5	10
4/23/2012	SW010	19.944										7	20
5/9/2012	SW010	20.5										4	31
11/14/2012	SW010	11.611										84	450
12/13/2012	SW010	5.111										480	53
1/25/2012	SW011	6										82	75
2/29/2012	SW011	1.333										70	42
3/21/2012	SW011	7.222										60	20
4/23/2012	SW011	17										80	53
5/9/2012	SW011	15										48	20
6/21/2012	SW011	17.972										400	120
7/18/2012	SW011	15.444										54	54
10/16/2012	SW011	15.833										2400	2000
11/14/2012	SW011	10.5835										180	160
12/13/2012	SW011	6.222										52	20
1/25/2012	SW012	8.25										46	20
2/29/2012	SW012	0.611										20	20
3/21/2012	SW012	11.722										6	9
4/23/2012	SW012	21.222										94	9
5/9/2012	SW012	18.889										54	9
6/21/2012	SW012	19										100	9
11/14/2012	SW012	12.111										29	53
12/13/2012	SW012	6.222										31	42
1/25/2012	SW013	7.5										170	20
2/29/2012	SW013	0.444										64	9
3/21/2012	SW013	10.889										6	9
4/23/2012	SW013	19.056										6	9
5/9/2012	SW013	17.389										35	290
6/21/2012	SW013	22.167										44	53

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
11/14/2012	SW013	12										31	410
12/13/2012	SW013	5.222										400	120
1/25/2012	SW014	5.5										20	9
2/29/2012	SW014	0.722							0.013	0.0051	0.045	28	20
3/21/2012	SW014	9.667										8	9
4/23/2012	SW014	16.778										66	9
5/9/2012	SW014	15.222							0.0063	0.0027		78	20
6/21/2012	SW014	20.444										16	9
7/18/2012	SW014	19										20	20
10/16/2012	SW014	15.833											
11/14/2012	SW014	11.661							0.016	0.0031	0.047	66	64
12/13/2012	SW014	5.944										20	20
1/13/2012	SW015	2										10	10
2/21/2012	SW015	7.963	110	0.63		2.3	33.9	12				6	64
3/13/2012	SW015	6.611										6	9
4/18/2012	SW015	14.167										13	10
5/22/2012	SW015	17.944	110	0.045		5.1	41.5	32				60	20
6/13/2012	SW015	23.944										140	10
7/23/2012	SW015	17.1665										320	320
11/8/2012	SW015	10.889	95	0.36		3.6	60	8.7				14	450
12/14/2012	SW015	5.389										22	31
1/13/2012	SW016	3										2	9
2/21/2012	SW016	7.778										350	740
3/13/2012	SW016	6.5										4	20
4/18/2012	SW016	16.722										1.9	9
5/22/2012	SW016	17.222										55	9
6/13/2012	SW016	20.056										37	10
11/8/2012	SW016	13.111										16	120
12/14/2012	SW016	5.389										96	31
1/13/2012	SW017	4.75										2	9
2/21/2012	SW017	7.778										84	31
3/13/2012	SW017	6.556										8	9
4/18/2012	SW017	16.944										4	10
5/22/2012	SW017	14.556										80	75
6/13/2012	SW017	15										4.9	9
12/14/2012	SW017	5.556										58	150
1/10/2012	SW019	8.5										1.9	53
2/1/2012	SW019	9										1.9	9
3/6/2012	SW019	7										1.9	9
4/4/2012	SW019	10										1.9	9
5/16/2012	SW019	16.389										1.9	9
6/27/2012	SW019	23.889										12	9
7/11/2012	SW019	19.4165										36	36
8/9/2012	SW019	23.083										18	9

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
9/6/2012	SW019	21.944										2	9
10/9/2012	SW019	12.222										4	9
11/27/2012	SW019	9.056										7	9
1/10/2012	SW022	8										1.9	9
2/1/2012	SW022	10										1.9	9
3/6/2012	SW022	8.222										1.9	9
4/4/2012	SW022	10.444										1.9	20
5/16/2012	SW022	16.222										2	9
6/27/2012	SW022	21.278										1.9	9
7/11/2012	SW022	19.056										1.9	1.9
8/9/2012	SW022	23.722										1.9	9
9/6/2012	SW022	20.667										2	9
10/9/2012	SW022	12.278										1.9	9
11/27/2012	SW022	9.611										1.9	9
1/10/2012	SW023											1.9	9
2/1/2012	SW023	9										26	42
3/6/2012	SW023	7.056										20	20
5/16/2012	SW023	17.944										4	9
6/27/2012	SW023	17.556										16	20
7/11/2012	SW023	17.778										18	18
8/9/2012	SW023	19.778										38	20
9/6/2012	SW023	20.444										1.9	9
10/9/2012	SW023	13										1.9	9
11/27/2012	SW023	7.111										27	9
1/10/2012	SW026	7.5										8	31
2/1/2012	SW026	8										72	9
3/6/2012	SW026	6.444										4	20
4/4/2012	SW026	13										20	9
5/16/2012	SW026	19.778										53	9
11/27/2012	SW026	6.167										49	31
1/10/2012	SW027	5										4	9
2/1/2012	SW027	7										18	9
3/6/2012	SW027	4.639										48	9
4/4/2012	SW027	10.6945										4	9
5/16/2012	SW027	17.278										52	340
6/27/2012	SW027	17.611										110	1100
7/11/2012	SW027	18.444										110	110
11/27/2012	SW027	5.222										1.9	9
1/10/2012	SW028	7										8	9
2/1/2012	SW028	8										58	42
3/6/2012	SW028	9.6945										40	10
4/4/2012	SW028	13.5										56	9
5/16/2012	SW028	17.833										1.9	9
11/27/2012	SW028	7.2225										25	20

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
1/31/2012	SW029	8.5										42	9
2/7/2012	SW029	7.5										38	9
3/20/2012	SW029	6.889										14	10
4/17/2012	SW029	9.111										4	10
5/29/2012	SW029	12.056										1100	75
6/12/2012	SW029	14.056										2400	530
11/28/2012	SW029	8.889										36	9
12/11/2012	SW029	6.278										29	9
1/31/2012	SW030	7										940	1600
2/7/2012	SW030	10.5										6	9
3/20/2012	SW030	7.778										10	20
4/17/2012	SW030	11										44	9
5/29/2012	SW030	17.556										30	10
6/12/2012	SW030	40.489										75	9
7/12/2012	SW030	22.944										26	26
8/8/2012	SW030	20.6945										67	10
9/21/2012	SW030	15.833										26	31
10/26/2012	SW030	6.889										16	10
11/28/2012	SW030	7.167										20	20
12/11/2012	SW030	5.889										34	9
1/31/2012	SW031	7										12	9
2/7/2012	SW031	9.75										2	9
3/20/2012	SW031	8.389										6	9
4/17/2012	SW031	11.4725										26	9
5/29/2012	SW031	16										22	9
6/12/2012	SW031	20.222										18	31
11/28/2012	SW031	6.667										4	9
12/11/2012	SW031	6.056										14	9
1/31/2012	SW032	7										54	140
2/7/2012	SW032	11										1.9	9
3/20/2012	SW032	8										3	9
4/17/2012	SW032	11.5										26	10
5/29/2012	SW032	15.833										6	9
6/12/2012	SW032	21.333										20	9
7/12/2012	SW032	24.611										22	22
8/8/2012	SW032	22.278										12	10
9/21/2012	SW032	15.111										44	20
10/26/2012	SW032	7.889										25	31
11/28/2012	SW032	6.944										15	31
12/11/2012	SW032	5.889										56	20
1/31/2012	SW033	6.75										14	9
2/7/2012	SW033	11										6	9
3/20/2012	SW033	9.5835										2	9
4/17/2012	SW033	10.556										16	9

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
6/12/2012	SW033	18.8885										68	10
11/28/2012	SW033	6.944										5	9
12/11/2012	SW033	6.333										16	9
1/31/2012	SW034	6.5										62	180
2/7/2012	SW034	10.5										4	9
3/20/2012	SW034	9.778										1.9	20
4/17/2012	SW034	10.167										32	10
5/29/2012	SW034	17.889										2	9
6/12/2012	SW034	20.611										26	10
7/12/2012	SW034	22.139										80	80
8/8/2012	SW034	19.389										26	10
9/21/2012	SW034	14.833										56	64
10/26/2012	SW034	8.167										26	20
11/28/2012	SW034	6.833										9	31
12/11/2012	SW034	6										330	64
1/31/2012	SW035	7.5										1.9	9
2/7/2012	SW035	12.5										2	9
3/20/2012	SW035	9.389										1.9	20
4/17/2012	SW035	9.6945										4	9
1/31/2012	SW036	6										88	99
2/7/2012	SW036	10.5										4	9
3/20/2012	SW036	6.889										4	20
4/17/2012	SW036	10.278										36	20
5/29/2012	SW036	16.861										2	9
6/12/2012	SW036	20.556										10	9
7/12/2012	SW036	19.667										92	92
8/8/2012	SW036	20.111										24	10
9/21/2012	SW036	14.222										32	310
10/26/2012	SW036	8.611										25	53
11/28/2012	SW036	7.389										1.9	10
12/11/2012	SW036	6.667										18	10
2/7/2012	SW037	13										1.9	9
1/31/2012	SW038	8										100	160
2/7/2012	SW038	11										6	9
3/20/2012	SW038	10.444										1.9	9
4/17/2012	SW038	10.222										32	10
5/29/2012	SW038	17.222										6	9
6/12/2012	SW038	19.333										10	9
7/12/2012	SW038	21.222										44	44
8/8/2012	SW038	19.167										62	10
9/21/2012	SW038	12.056										24	53
10/26/2012	SW038	8.722										13	20
11/28/2012	SW038	7.889										5	9
12/11/2012	SW038	6.444										5	20

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
1/31/2012	SW039	8										34	99
2/7/2012	SW039	12										2	9
3/20/2012	SW039	7.5										2	9
4/17/2012	SW039	10.278										1.9	9
5/29/2012	SW039	17.5										2	9
6/12/2012	SW039	18.333										1.9	9
7/12/2012	SW039	18.667										2	2
8/8/2012	SW039	20.944										74	140
9/21/2012	SW039	13.444										340	2000
10/26/2012	SW039	10.5										2	9
11/28/2012	SW039	26.889										16	20
12/11/2012	SW039											9	31
1/13/2012	SW051	3										12	9
1/25/2012	SW051	6										130	20
2/21/2012	SW051	7.111										6	20
2/29/2012	SW051	2.778										8	9
3/13/2012	SW051	4.889										20	31
3/21/2012	SW051	8.111										20	10
4/18/2012	SW051	13.611										10	9
4/23/2012	SW051	16.222										10	10
5/9/2012	SW051	12.167										24	10
5/22/2012	SW051	14.333										54	9
6/13/2012	SW051	16.833										1.9	10
6/21/2012	SW051	17.778										36	20
7/18/2012	SW051	16.444										10	10
7/23/2012	SW051	15.222										26	26
8/16/2012	SW051	24.611										16	42
8/28/2012	SW051	16.667										8	9
9/13/2012	SW051	15.333										6	9
9/14/2012	SW051	19.111										340	9
10/16/2012	SW051	14.222										110	9
10/19/2012	SW051	14.389										32	9
11/8/2012	SW051	12										42	110
11/14/2012	SW051	11.222										82	380
12/13/2012	SW051	7.944										56	87
12/14/2012	SW051	6.278										56	31
1/13/2012	SW052	4.5										1.9	9
2/21/2012	SW052	7.167										1.9	9
3/13/2012	SW052	4.111										1.9	9
4/18/2012	SW052	13.056										1.9	9
5/22/2012	SW052	13.556										1.9	9
6/13/2012	SW052	17.333										1.9	9
7/23/2012	SW052	15.444										1.9	1.9
8/16/2012	SW052	24.333										1.9	9

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
9/14/2012	SW052	19.4445										1.9	9
10/19/2012	SW052	14.1665										22	20
11/8/2012	SW052	13.667										1.9	9
12/14/2012	SW052	5.389										2	9
1/25/2012	SW053	5.5										48	110
2/29/2012	SW053	2.778										30	9
3/21/2012	SW053	9.611										20	9
4/23/2012	SW053	15.6945										68	10
5/9/2012	SW053	13.5										24	10
6/21/2012	SW053	21.444										42	20
7/18/2012	SW053	17.7225										24	24
8/28/2012	SW053	17.889										14	9
9/13/2012	SW053	17.778										6	9
10/16/2012	SW053	15.111										170	42
11/14/2012	SW053	12.111										180	830
12/13/2012	SW053	6										50	10
1/13/2012	SW055	2										50	10
2/21/2012	SW055	7.667										14	10
3/13/2012	SW055	3.722										4	9
4/18/2012	SW055	12.722										14	9
5/22/2012	SW055	15.167										14	9
6/13/2012	SW055	18.611										6	20
7/23/2012	SW055	15.667										72	72
8/16/2012	SW055	27.083										1.9	250
9/14/2012	SW055	19.056										2	10
10/19/2012	SW055	13.611										85	10
11/8/2012	SW055	13.556										2400	480
12/14/2012	SW055	7.444										72	20
2/21/2012	SW056	7.222										32	99
3/13/2012	SW056	4.778										10	53
4/18/2012	SW056	12.278										36	9
5/22/2012	SW056	12.222										640	110
6/13/2012	SW056	18.0555										160	31
7/23/2012	SW056	14.778										90	90
8/16/2012	SW056	23.722										8	220
9/14/2012	SW056	20.167										24	20
10/19/2012	SW056	13.611										74	64
11/8/2012	SW056	13.278										160	380
12/14/2012	SW056	5.111										62	9
1/13/2012	SW059	4.5										14	9
2/21/2012	SW059											52	290
3/13/2012	SW059	4.444										38	53
4/18/2012	SW059	13.361										120	9
5/22/2012	SW059	15.833										110	10

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
6/13/2012	SW059	18.167										160	31
10/19/2012	SW059	15.278										240	410
11/8/2012	SW059	10.861										29	150
12/14/2012	SW059	4.9445										780	140
1/13/2012	SW072	3.25										16	9
2/21/2012	SW072	6.667										18	10
3/13/2012	SW072	5.222										18	9
4/18/2012	SW072	13.611										72	9
5/22/2012	SW072	17.333										1100	160
6/13/2012	SW072	22.278										170	9
7/23/2012	SW072	17.722										130	130
8/16/2012	SW072	26.833										110	660
10/19/2012	SW072	9.778										1.9	31
11/8/2012	SW072	12.889										4	31
12/14/2012	SW072	6.278										31	9
1/13/2012	SW118	4.75										6	9
1/25/2012	SW118	7.5										160	120
1/31/2012	SW118	8										94	10
2/7/2012	SW118	10										14	9
2/21/2012	SW118	7.833										88	31
2/29/2012	SW118	1.389										6	9
3/13/2012	SW118	6.722										110	10
3/20/2012	SW118	7										10	9
3/21/2012	SW118	10.111										8	9
4/17/2012	SW118	10.889										46	31
4/18/2012	SW118	11.889										14	10
4/23/2012	SW118	19.333										28	10
5/9/2012	SW118	13.556										28	20
5/29/2012	SW118	14.667										12	9
6/12/2012	SW118	16.389										32	9
6/13/2012	SW118	15.556										88	20
6/21/2012	SW118	21.111										34	53
7/12/2012	SW118	15.556										28	28
7/18/2012	SW118	16.556										58	58
7/23/2012	SW118	15										74	74
8/8/2012	SW118	21.167										42	20
8/16/2012	SW118	22.556										440	560
8/28/2012	SW118	18.389										44	9
9/13/2012	SW118	23.333										22	10
9/14/2012	SW118	22.556										10	20
9/21/2012	SW118	15.833										28	10
10/16/2012	SW118	14.611										2400	31
10/19/2012	SW118	11.667										2400	2000
10/26/2012	SW118	8.278										20	20
11/8/2012	SW118	10.889										29	10
11/14/2012	SW118	10.444										120	99
11/28/2012	SW118	6.8885										16	9
12/11/2012	SW118	5.389										27	10

Table A.1 2012 Selected Water Quality Results

Run Date	Site Number	Air Temperature (deg C)	Alkalinity (mg/l)	Ammonia (mg/l)	Arsenic (mg/l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Chlorophyll a (ug/l)	Chromium (mg/l)	Copper (mg/l)	Diesel Range Plus (mg/l)	E_ coli (cfu/100ml)	Enterococcus (cfu/100ml)
12/13/2012	SW118	6.889										40	31
12/14/2012	SW118	1/5/1900										3/12/1900	2/11/1900

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
1/10/2012	SW001	1.9	11										91.9
1/10/2012	SW002	8	6										97.3
1/10/2012	SW006	1.9	4										96.25
1/10/2012	SW019	1.9	5										94.1
1/10/2012	SW022	1.9	6										92.95
1/10/2012	SW023	1.9	1										92.7
1/10/2012	SW026	8	11										119.4
1/10/2012	SW027	4	11										43.6
1/10/2012	SW028	8	11										110.5
1/13/2012	SW015	10	11										42.4
1/13/2012	SW016	2	11										89.05
1/13/2012	SW017	2	1										7
1/13/2012	SW051	12	11										89.1
1/13/2012	SW052	1.9	8										115.7
1/13/2012	SW055	50	1										50.8
1/13/2012	SW059	14	11										60.5
1/13/2012	SW072	16	1										21.8
1/13/2012	SW118	6	11										100.55
1/25/2012	SW003	86	11										80.1
1/25/2012	SW008	80	11										90.9
1/25/2012	SW009	4	1										11.6
1/25/2012	SW010	55	11										75.2
1/25/2012	SW011	82	11										108.5
1/25/2012	SW012	46	11										80.2
1/25/2012	SW013	170	1										73.2
1/25/2012	SW014	20	11										86
1/25/2012	SW051	130	10										102.2
1/25/2012	SW053	48	6										96.55
1/25/2012	SW118	160	11										102.4
1/31/2012	SW007	80	11										98.9
1/31/2012	SW029	42	11										93.1
1/31/2012	SW030	940	2										103
1/31/2012	SW031	12	11										66.9
1/31/2012	SW032	54	9										103.6
1/31/2012	SW033	14	11										51.35
1/31/2012	SW034	62	9										102.7
1/31/2012	SW035	1.9	11										57.7
1/31/2012	SW036	88	9										102.7
1/31/2012	SW038	100	9										103.5
1/31/2012	SW039	34	2										101.9
1/31/2012	SW118	94	11										100
2/1/2012	SW001	4	1										94.15
2/1/2012	SW002	2	7										99.45
2/1/2012	SW006	46	9										102.9

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
2/1/2012	SW019	1.9	1										100.2
2/1/2012	SW022	1.9	7										100.3
2/1/2012	SW023	26	9										101
2/1/2012	SW026	72	11										81.7
2/1/2012	SW027	18	11										89.8
2/1/2012	SW028	58	11										93.4
2/7/2012	DH048	1.7											
2/7/2012	DH049	2											
2/7/2012	DH050	2											
2/7/2012	DH051	23											
2/7/2012	DH052	17											
2/7/2012	DH053	4.5											
2/7/2012	DH054	1.7											
2/7/2012	DH055	2											
2/7/2012	DH057	4.5											
2/7/2012	DH058	79											
2/7/2012	DH271	13											
2/7/2012	DH272	1.7											
2/7/2012	SW007	6	11										101.5
2/7/2012	SW029	38	11										97.4
2/7/2012	SW030	6	7										105.9
2/7/2012	SW031	2	11										68.15
2/7/2012	SW032	1.9	7										106.2
2/7/2012	SW033	6	11										61.3
2/7/2012	SW034	4	8										112.8
2/7/2012	SW035	2	11										61
2/7/2012	SW036	4	8										113.8
2/7/2012	SW037	1.9	11										78
2/7/2012	SW038	6	8										120.5
2/7/2012	SW039	2	2										118
2/7/2012	SW118	14	11										102.5
2/15/2012	DH038	1.7	6										93.6
2/15/2012	DH039	2	6										91.95
2/15/2012	DH040	49	6										91.5
2/15/2012	DH041	1.7	6										90.9
2/15/2012	DH042	2	6										92.5
2/15/2012	DH043	2	6										92.3
2/15/2012	DH044	1.7	1										117.6
2/15/2012	DH045	1.7	8										124.8
2/15/2012	DH285	2	1										104.2
2/15/2012	DH286	4.5	1										96.6
2/15/2012	DH287	2	5										96.2
2/15/2012	DH288	1.7	1										98.3
40960	SW015	6	11			3.5				0.38	0.045	0.045	69.4

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
2/21/2012	SW016	350	11										92.4
2/21/2012	SW017	84	11										82.9
2/21/2012	SW051	6	10										92
2/21/2012	SW052	1.9	1										103.7
2/21/2012	SW055	14	1										82.1
2/21/2012	SW056	32	1										86.3
2/21/2012	SW059	52	11										65.8
2/21/2012	SW072	18	1										65.1
2/21/2012	SW118	88	11										96.4
2/29/2012	SW003	10	11			4				0.47	0.045	0.23	75.5
2/29/2012	SW008	42	11										84.9
2/29/2012	SW009	4.9	1			33				0.045	0.045	0.045	17.8
2/29/2012	SW010	40	11										79.4
2/29/2012	SW011	70	11										99.9
2/29/2012	SW012	20	11										86.7
2/29/2012	SW013	64	11										99.8
2/29/2012	SW014	36	0.498611093		62		0.0011	0.09					88.4
2/29/2012	SW051	8	10										103.4
2/29/2012	SW053	30	11										93.9
2/29/2012	SW118	6	11										99.3
3/6/2012	SW001	1.9	10										95.1
3/6/2012	SW002	1.9	3										107.9
3/6/2012	SW006	24	4										103.4
3/6/2012	SW019	1.9	5										98.6
3/6/2012	SW022	1.9	4										102
3/6/2012	SW023	20	9										103.6
3/6/2012	SW026	4	11										102.3
3/6/2012	SW027	48	11										98.85
3/6/2012	SW028	40	11										124.75
3/13/2012	SW015	6	11										75
3/13/2012	SW016	4	11										78.7
3/13/2012	SW017	8	11										77.1
3/13/2012	SW051	20	10										93.8
3/13/2012	SW052	1.9	1										104.8
3/13/2012	SW055	4	1										80
3/13/2012	SW056	10	11										83.2
3/13/2012	SW059	38	11										74.4
3/13/2012	SW072	18	1										66
3/13/2012	SW118	110	11										98.25
3/20/2012	SW007	1.9	11										95.4
3/20/2012	SW029	14	11										96
3/20/2012	SW030	10	9										99.7
3/20/2012	SW031	6	11										85.1
3/20/2012	SW032	3	9										99.5

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
3/20/2012	SW033	2	11										65.7
3/20/2012	SW034	1.9	8										98.9
3/20/2012	SW035	1.9	11										70.3
3/20/2012	SW036	4	9										109.2
3/20/2012	SW038	1.9	9										111.4
3/20/2012	SW039	2	7										101
3/20/2012	SW118	10	11										99.1
3/21/2012	SW003	30	11										70
3/21/2012	SW008	8	11										73.7
3/21/2012	SW009	1.9	1										3.8
3/21/2012	SW010	5	11										82.3
3/21/2012	SW011	60	11										102.3
3/21/2012	SW012	6	11										90.8
3/21/2012	SW013	6	11										123.2
3/21/2012	SW014	8	11										91.2
3/21/2012	SW051	20											99.8
3/21/2012	SW053	20	11										79.05
3/21/2012	SW118	8	11										106.7
4/4/2012	SW001	1.9	11										103.2
4/4/2012	SW002	1.9	3										116.5
4/4/2012	SW006	6	4										101.9
4/4/2012	SW019	1.9	11										99.8
4/4/2012	SW022	1.9	3										99.1
4/4/2012	SW026	20	11										106.9
4/4/2012	SW027	4	11										96.1
4/4/2012	SW028	56	11										145
4/11/2012	DH038	1.7	6										103.8
4/11/2012	DH039	2	6										111.5
4/11/2012	DH040	1.7	6										102.6
4/11/2012	DH041	1.7	6										101.8
4/11/2012	DH042	1.7	6										146
4/11/2012	DH043	2	6										111.85
4/11/2012	DH044	1.7	1										100
4/11/2012	DH045	1.7	8										125.8
4/11/2012	DH285	1.7	6										139.3
4/11/2012	DH286	1.7	1										144.2
4/11/2012	DH287	1.7	6										119
4/11/2012	DH288	2	1										118.3
4/17/2012	DH048	1.7											
4/17/2012	DH049	11											
4/17/2012	DH050	49											
4/17/2012	DH051	13											
4/17/2012	DH052	49											
4/17/2012	DH053	1.7											

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
4/17/2012	DH054	13											
4/17/2012	DH055	13											
4/17/2012	DH057	46											
4/17/2012	DH058	33											
4/17/2012	DH271	79											
4/17/2012	DH272	31											
4/17/2012	SW007	68	11										99.8
4/17/2012	SW029	4	11										99.2
4/17/2012	SW030	44	7										104.7
4/17/2012	SW031	26	11										85.55
4/17/2012	SW032	26	7										106
4/17/2012	SW033	16	11										72.3
4/17/2012	SW034	34	6										103.9
4/17/2012	SW035	4	11										85.4
4/17/2012	SW036	38	7										107.2
4/17/2012	SW038	32	7										109.1
4/17/2012	SW039	1.9	7										142.2
4/17/2012	SW118	46	11										99.3
4/18/2012	SW015	13	1										94
4/18/2012	SW016	1.9	11										191.8
4/18/2012	SW017	4	1										36.5
4/18/2012	SW051	10	10										95.1
4/18/2012	SW052	1.9											116.9
4/18/2012	SW055	14	11										71.2
4/18/2012	SW056	36											98.9
4/18/2012	SW059	120	11										100.6
4/18/2012	SW072	72	2										41.9
4/18/2012	SW118	14	11										101.9
4/23/2012	SW003	42	11										59.4
4/23/2012	SW008	26	1										54.4
4/23/2012	SW009	20	1										115.7
4/23/2012	SW010	7	11										100.9
4/23/2012	SW011	80	11										105.8
4/23/2012	SW012	94	11										58.3
4/23/2012	SW013	6	11										29.2
4/23/2012	SW014	66	11										83.2
4/23/2012	SW051	10	11										92.9
4/23/2012	SW053	68	11										84
4/23/2012	SW118	28	11										103.3
5/9/2012	SW003	28	11			3.4				0.045	0.045	0.045	45.85
5/9/2012	SW008	200	11										51.4
5/9/2012	SW009	170	1			110				0.045	0.45	0.08	2.6
5/9/2012	SW010	4	11										110.5
5/9/2012	SW011	48	11										106.6

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
5/9/2012	SW012	54	11										51.1
5/9/2012	SW013	35	1										12.4
5/9/2012	SW014	78	11		60		0.00045	0.117					76.3
5/9/2012	SW051	24	11										94.7
5/9/2012	SW053	24	11										88.9
5/9/2012	SW118	28	11										103.1
5/16/2012	SW001	1.9	3		5200			0.09	0.00018				144.3
5/16/2012	SW002	1.9	3			0.286				0.018	0.018	0.034	171.85
5/16/2012	SW006	6	5			0.812						0.048	120
5/16/2012	SW019	1.9	5										141
5/16/2012	SW022	2	3										112.8
5/16/2012	SW023	4	8										119.9
5/16/2012	SW026	53	11										43.3
5/16/2012	SW027	52	11										97
5/16/2012	SW028	1.9	1										219.7
5/22/2012	SW004	460	11										101
5/22/2012	SW015	60	1			1.6				0.045	0.045	0.045	79.4
5/22/2012	SW016	55	11										66.6
5/22/2012	SW017	80	1										14.5
5/22/2012	SW051	54	10										91.5
5/22/2012	SW052	1.9	2										111
5/22/2012	SW055	14	1										63.7
5/22/2012	SW056	640	11										116.1
5/22/2012	SW059	110	11										50.3
5/22/2012	SW072	1100	11										74.85
5/29/2012	SW007	20	11										101.8
5/29/2012	SW029	1100	11										89.4
5/29/2012	SW030	30	2										105.4
5/29/2012	SW031	22	11										65.5
5/29/2012	SW032	6	2										119
5/29/2012	SW034	2	2										123
5/29/2012	SW036	2	9										105.9
5/29/2012	SW038	6	9										112.1
5/29/2012	SW039	2	7										111.5
5/29/2012	SW118	12	11										103.5
6/6/2012	DH038	1.7	6										98
6/6/2012	DH039	2	6										95.5
6/6/2012	DH040	1.7	6										95.9
6/6/2012	DH041	2	6										92.9
6/6/2012	DH042	1.7	6										106
6/6/2012	DH043	1.7	6										109.6
6/6/2012	DH044	22	1										97.85
6/6/2012	DH045	1.7	8										147.7
41066	DH285	1.7	6										94.3

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
6/6/2012	DH286	4.5	6										100.6
6/6/2012	DH287	1.7	6										93.2
6/6/2012	DH288	1.7	6										90
6/12/2012	DH048	7.8											
6/12/2012	DH049	70											
6/12/2012	DH050	31											
6/12/2012	DH051	13											
6/12/2012	DH052	23											
6/12/2012	DH053	2											
6/12/2012	DH054	4.5											
6/12/2012	DH055	17											
6/12/2012	DH057	13											
6/12/2012	DH058	1.7											
6/12/2012	DH271	17											
6/12/2012	DH272	4.5											
6/12/2012	SW007	66	11										98.5
6/12/2012	SW029	2400	11										89.6
6/12/2012	SW030	75	2										109.85
6/12/2012	SW031	18	11										64.8
6/12/2012	SW032	20	11										139.8
6/12/2012	SW033	68	11										50.45
6/12/2012	SW034	26	8										132.4
6/12/2012	SW036	10	1										115.9
6/12/2012	SW038	10	1										108.5
6/12/2012	SW039	1.9	1										163.3
6/12/2012	SW118	32	11										99.6
6/13/2012	SW015	140	1										84.3
6/13/2012	SW016	37											20.1
6/13/2012	SW017	4.9	1										44.4
6/13/2012	SW051	1.9	10										134.6
6/13/2012	SW052	1.9	2										136.8
6/13/2012	SW055	6	11										49.8
6/13/2012	SW056	160	11										90.05
6/13/2012	SW059	160	11										63.4
6/13/2012	SW072	170	1										52.6
6/13/2012	SW118	88	11										103.6
6/21/2012	SW003	32	11										56.3
6/21/2012	SW008	240	11										94.1
6/21/2012	SW009	160	1										22.7
6/21/2012	SW011	400	11										97.8
6/21/2012	SW012	100	1										199.8
6/21/2012	SW013	44	1										14.6
6/21/2012	SW014	16	1										61.9
6/21/2012	SW051	36	11										87.5

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
6/21/2012	SW053	42	11										84.3
6/21/2012	SW118	34	11										101.4
6/27/2012	SW001	1.9	11										107.1
6/27/2012	SW002	1.9	8										110.8
6/27/2012	SW006	2	1										104.8
6/27/2012	SW019	12	2										102
6/27/2012	SW022	1.9	1										105
6/27/2012	SW023	16	4										105.1
6/27/2012	SW027	110	11										98.3
7/11/2012	SW001	9	11										122.1
7/11/2012	SW002	9	6										146.6
7/11/2012	SW006	9	1										105.1
7/11/2012	SW019	9	6										111.6
7/11/2012	SW022	9	6										
7/11/2012	SW023	10	2										101.9
7/11/2012	SW027	740	11										95.4
7/12/2012	SW007	9	11										102.3
7/12/2012	SW030	31	6										104.4
7/12/2012	SW032	9	4										105.5
7/12/2012	SW034	9	6										102.4
7/12/2012	SW036	9	8										110.1
7/12/2012	SW038	10	8										109.3
7/12/2012	SW039	9	6										166.1
7/12/2012	SW118	9	11										100
7/18/2012	SW003	220	11										56
7/18/2012	SW008	340	11										20.9
7/18/2012	SW011	42	11										78.4
7/18/2012	SW014	31	11										38
7/18/2012	SW051	250	10										55
7/18/2012	SW053	75	11										32.35
7/18/2012	SW118	87	11										97.8
7/23/2012	SW015	500	11										59.15
7/23/2012	SW051	9											89.6
7/23/2012	SW052	9											103.9
7/23/2012	SW055	42	1										66.5
7/23/2012	SW056	87											120.8
7/23/2012	SW072	180	1										19.1
7/23/2012	SW118	53	11										108
8/1/2012	DH038	1.7											120.8
8/1/2012	DH039	1.7											96.3
8/1/2012	DH040	1.7											95.5
8/1/2012	DH041	1.7											195
8/1/2012	DH042	1.7											194.8
8/1/2012	DH043	1.7											124

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
8/1/2012	DH044	2											130.6
8/1/2012	DH045	1.7											163.9
8/1/2012	DH285	2	2										99
8/1/2012	DH286	1.7	6										141.5
8/1/2012	DH287	1.7	2										89.4
8/1/2012	DH288	2											123.7
8/8/2012	DH048	1.7											
8/8/2012	DH049	2											
8/8/2012	DH050	2											
8/8/2012	DH051	2											
8/8/2012	DH052	6.8											
8/8/2012	DH053	1.7											
8/8/2012	DH054	1.7											
8/8/2012	DH055	1.7											
8/8/2012	DH057	1.7											
8/8/2012	DH058	1.7											
8/8/2012	DH271	1.7											
8/8/2012	DH272	1.7											
8/8/2012	SW007	48	11										101.1
8/8/2012	SW030	67	3										109.35
8/8/2012	SW032	12	3										106.5
8/8/2012	SW034	26	2										105.2
8/8/2012	SW036	24	4										104.7
8/8/2012	SW038	62	4										106
8/8/2012	SW039	74	2										105.5
8/8/2012	SW118	42	11										104.8
8/9/2012	SW001	4	1		4980			0.09	0.00045				93.5
8/9/2012	SW002	2	1			0.0398						0.018	173.4
8/9/2012	SW006	12	8			0.541						0.046	107
8/9/2012	SW019	18	6										92.3
8/9/2012	SW022	1.9	1										132.5
8/9/2012	SW023	38	8										97.8
8/16/2012	SW051	16	11										41.5
8/16/2012	SW052	1.9											101.1
8/16/2012	SW055	1.9	11										39.75
8/16/2012	SW056	8	11										124.4
8/16/2012	SW072	110											0.16
8/16/2012	SW118	440	11										99.3
8/28/2012	SW003	130	11			0.33				0.045		0.11	109
8/28/2012	SW008	30	1										23.85
8/28/2012	SW051	8											60.7
8/28/2012	SW053	14	11										66.6
8/28/2012	SW118	44	11										99.6
9/6/2012	SW001	6	11										110.4

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
9/6/2012	SW002	1.9	4										141.9
9/6/2012	SW006	2	5										119.3
9/6/2012	SW019	2											106.2
9/6/2012	SW022	2	1										132.4
9/6/2012	SW023	1.9	6										108.9
9/13/2012	SW003	54	11										81
9/13/2012	SW008	26	1										105.7
9/13/2012	SW051	6	10										99
9/13/2012	SW053	6	11										65.4
9/13/2012	SW118	22	11										118.15
9/14/2012	SW051	340	10										62.3
9/14/2012	SW052	1.9											101.05
9/14/2012	SW055	2	11										78.5
9/14/2012	SW056	24	10										133.4
9/14/2012	SW118	10	11										106.8
9/21/2012	SW007	320	1										43.3
9/21/2012	SW030	28											104.2
9/21/2012	SW032	44	3										105.8
9/21/2012	SW034	56	3										102.85
9/21/2012	SW036	32	1										101.8
9/21/2012	SW038	24	1										101.9
9/21/2012	SW039	340	7										98.1
9/21/2012	SW118	28	11										101.4
10/9/2012	SW001	9	10										83.8
10/9/2012	SW002	2	2										92.8
10/9/2012	SW006	1.9	2										134.5
10/9/2012	SW019	4	2										76.3
10/9/2012	SW022	1.9	3										89.3
10/9/2012	SW023	1.9	1										125.4
10/16/2012	SW003	560	1										59.05
10/16/2012	SW008	2400	11										57.4
10/16/2012	SW011	2400	11										57.9
10/16/2012	SW014		1										54.1
10/16/2012	SW051	110	10										86.1
10/16/2012	SW053	170	11										78.6
10/16/2012	SW118	2400	11										102.4
10/19/2012	SW051	32	10										90.2
10/19/2012	SW052	22	3										106.25
10/19/2012	SW055	85	1										130.8
10/19/2012	SW056	74	1										77
10/19/2012	SW059	240	10										82.1
10/19/2012	SW072	1.9	1										38.7
10/19/2012	SW118	2400	11										98.8
10/23/2012	DH048	6.8											

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
10/23/2012	DH049	23											
10/23/2012	DH050	17											
10/23/2012	DH051	17											
10/23/2012	DH052	49											
10/23/2012	DH053	21											
10/23/2012	DH054	11											
10/23/2012	DH055	46											
10/23/2012	DH057	11											
10/23/2012	DH058	4											
10/23/2012	DH271	13											
10/23/2012	DH272	4.5											
10/26/2012	SW007	140	1										50.4
10/26/2012	SW030	16	3										91.9
10/26/2012	SW032	25	3										99
10/26/2012	SW034	26											99.2
10/26/2012	SW036	25											98.05
10/26/2012	SW038	13	1										98.5
10/26/2012	SW039	2	1										65.8
10/26/2012	SW118	20	11										101.5
11/8/2012	SW015	20	11			3.9				1.3	0.08	0.045	18.8
11/8/2012	SW016	16	11										38.8
11/8/2012	SW051	42	11										83
11/8/2012	SW052	1.9	1										114.6
11/8/2012	SW055	2400	10										44.8
11/8/2012	SW056	160	10										37.6
11/8/2012	SW059	29	11										29.25
11/8/2012	SW072	4	1										2.7
11/8/2012	SW118	29	11										101.6
11/14/2012	SW003	90	11			1.4				0.4	0.045	0.08	57
11/14/2012	SW008	110	11										58.1
11/14/2012	SW010	84	11										37
11/14/2012	SW011	180	11										99.3
11/14/2012	SW012	29	11										56.5
11/14/2012	SW013	31	11										47.4
11/14/2012	SW014	66	11		57		0.00045						68.7
11/14/2012	SW051	82	11										72.8
11/14/2012	SW053	180	11										62.3
11/14/2012	SW118	120	11										101
11/26/2012	DH038	2	7										85.45
11/26/2012	DH039	1.7	7										86.5
11/26/2012	DH040	1.7	7										87.6
11/26/2012	DH041	7.8	5										90
11/26/2012	DH042	9.3	5										86.5
11/26/2012	DH043	6.8	5										81.2
11/26/2012	DH044	1.7	1										102.8
11/26/2012	DH045	1.7	1										133.4
11/26/2012	DH285	2	2										85.4
11/26/2012	DH286	2	7										91.6

Table A.2 2012 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
11/26/2012	DH287	4.5	6										85
11/26/2012	DH288	2	6										93.3
11/27/2012	SW001	1.9	11		5000			0.09	0.00018				74.4
11/27/2012	SW002	5	1			0.0669						0.07	80.7
11/27/2012	SW006	13	1			0.325						0.06	84.8
11/27/2012	SW019	7	2										77.3
11/27/2012	SW022	13	1										83.4
11/27/2012	SW023	27	1										94.1
11/27/2012	SW026	49	11										87.8
11/27/2012	SW027	22	11										91.8
11/27/2012	SW028	25	11										90.6
11/28/2012	SW007	20	11										96.5
11/28/2012	SW029	36	11										108.6
11/28/2012	SW030	20	1										95.9
11/28/2012	SW031	4	11										92.5
11/28/2012	SW032	15	1										88.9
11/28/2012	SW033	5	11										49.9
11/28/2012	SW034	9	1										89.1
11/28/2012	SW036	9	2										108.3
11/28/2012	SW038	5	3										94
11/28/2012	SW039	16	4										83.8
11/28/2012	SW118	20	11										96.9
12/6/2012	DH038	1.7	4										95.3
12/6/2012	DH039	1.7	4										94.6
12/6/2012	DH040	4.5	4										90.4
12/6/2012	DH041	7.8	4										94.6
12/6/2012	DH042	7.8	4										95.5
12/6/2012	DH043	11	6										97
12/6/2012	DH044	23	1										102
12/6/2012	DH045	1.7	1										122.25
12/6/2012	DH285	17	4										100.2
12/6/2012	DH286	4.5	4										105.8
12/6/2012	DH287	2	4										96.5
12/6/2012	DH288	1.7	4										96.9
12/11/2012	DH048	2											
12/11/2012	DH049	2											
12/11/2012	DH050	2											
12/11/2012	DH051	7.8											
12/11/2012	DH052	4.5											
12/11/2012	DH053	4.5											
12/11/2012	DH054	1.7											
12/11/2012	DH055	1.7											
12/11/2012	DH057	2											

Table A.2 2011 Selected Water Quality Results

Run Date	Site Number	Fecal Coliform (cfu/100ml)	Flow - Direction (None)	Flow (cfs)	Hardness (mg/l)	Iron (mg/l)	Lead (mg/l)	Lube Oil Range Hydrocarbons (mg/l)	Mercury (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Orthophosphate (mg/l)	Oxygen Saturation (%)
12/11/2012	DH271	6.8											
12/11/2012	DH272	4											
12/11/2012	SW007	38	11										98.1
12/11/2012	SW029	29	11										126.1
12/11/2012	SW030	34											103.2
12/11/2012	SW031	14	11										64.7
12/11/2012	SW032	56	3										102.3
12/11/2012	SW033	16	11										50.9
12/11/2012	SW034	330	2										102.7
12/11/2012	SW036	18	2										101.1
12/11/2012	SW038	5	2										107.3
12/11/2012	SW039	9	8										95.6
12/11/2012	SW118	27	11										97
12/13/2012	SW003	33	11										65.2
12/13/2012	SW008	780	11										71.1
12/13/2012	SW010	480	11										71
12/13/2012	SW011	52	11										96.7
12/13/2012	SW012	31	11										66.4
12/13/2012	SW013	400	11										61.05
12/13/2012	SW014	20	11										76.1
12/13/2012	SW051	56	10										83.4
12/13/2012	SW053	50	1										85.7
12/13/2012	SW118	40	11										101.1
12/14/2012	SW015	22	11										68.5
12/14/2012	SW016	96	11										87.8
12/14/2012	SW017	58	11										56.8
12/14/2012	SW051	56	10										89.2
12/14/2012	SW052	2	7										105.6
12/14/2012	SW055	72	11										47.8
12/14/2012	SW056	62	11										61.4
12/14/2012	SW059	780	11										61.85
12/14/2012	SW072	31	1										15.7
12/14/2012	SW118	72	11										94.6

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
2/15/2012	DH038	9.46	7.62		6.6		29.26	180		45799				
4/11/2012	DH038	9.97	7.72		8.78		29.44	140		45797				
6/6/2012	DH038	9.25	7.86		10.04		27.93	120		43546				
8/1/2012	DH038	10.3	8.3		14.7		27.68	190		42986				
11/26/2012	DH038	8.38	7.66		8.085		28.67	175		44779.5				
12/6/2012	DH038	9.38	7.6		8.1		27.94	240		43801				
2/15/2012	DH039	9.345	7.605		6.62		29.26	220		45798.5				
4/11/2012	DH039	10.7	7.88		8.83		29.36	200		45655				
6/6/2012	DH039	9.01	7.84		9.89		28.42	180		44257				
8/1/2012	DH039	8.53	8.29		12.8		28.31	240		43936				
11/26/2012	DH039	8.53	7.65		7.91		28.6	220		44694				
12/6/2012	DH039	9.32	7.57		8.17		27.69	220		43143				
2/15/2012	DH040	9.21	7.61		6.79		29.26	190		45765				
4/11/2012	DH040	9.96	7.74		8.4		29.39	190		45757				
6/6/2012	DH040	9.04	7.83		9.95		28.27	140		44048				
8/1/2012	DH040	8.475	8.255		12.6		28.325	220		43954				
11/26/2012	DH040	8.56	7.69		8.16		28.83	200		45002				
12/6/2012	DH040	8.865	7.57		8.36		28	210		43892.5				
2/15/2012	DH041	9.18	7.6		6.78		29.26	170		45773				
4/11/2012	DH041	9.98	7.7		8.43		29.27	160		45652				
6/6/2012	DH041	8.8	7.83		9.75		28.34	110		44162				
8/1/2012	DH041	15.75	8.85		18.3		26.22	180		10916				
11/26/2012	DH041	8.86	7.7		7.86		28.66	197		44791				
12/6/2012	DH041	9.3	7.58		8.25		28.02	210		43855				
2/15/2012	DH042	9.34	7.62		6.65		29.16	180		45642				
4/11/2012	DH042	13.55	8.23		10.52		28.99	180		45001				
6/6/2012	DH042	9.62	8.07		11.69		28.47	110		44198				
8/1/2012	DH042	15.49	8.83		18.3		27.53	190		42706				
11/26/2012	DH042	8.59	7.66		7.67		28.18	200		44131				
12/6/2012	DH042	9.42	7.53		8		28.06	230		43922				
2/15/2012	DH043	9.31	7.62		6.82		29.17	280		45635				
4/11/2012	DH043	10.71	7.805		8.9		29.43	200		45766.5				
6/6/2012	DH043	10.07	8.07		10.91		29.18	130		45247				
8/1/2012	DH043	10.72	8.38		14.6		27.56	220		42816				
11/26/2012	DH043	7.905	7.65		8.405		28.91	260		45091				
12/6/2012	DH043	9.52	7.29		8.1		28.27	240		44225				
2/15/2012	DH044	11.79	8.19		7.61		27.09			42595				
4/11/2012	DH044	9.29	7.96		13.74		27.17			42281				
6/6/2012	DH044	8.21	7.76		15.33		28.8			44522.5				
8/1/2012	DH044	9.53	8.3		23.4		27.08			42150				
11/26/2012	DH044	10.86	7.85		5.52		26.27			41667				
12/6/2012	DH044	10.48	7.74		6.68		26.52			41879				
2/15/2012	DH045	12.765	8.235		6.705		27.135			42752				
4/11/2012	DH045	11.39	8.05		12.14		27.32			42556				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
6/6/2012	DH045	12.3	8.08		15.63		28.96			44717				
8/1/2012	DH045	12.62	8.63		22.1		27.23			42397				
11/26/2012	DH045	13.99	8.05		5.5		26.33			41755				
12/6/2012	DH045	12.545	7.905		6.715		26.615			42006				
2/7/2012	DH048						26							
4/17/2012	DH048						30							
6/12/2012	DH048						10							
8/8/2012	DH048						20							
10/23/2012	DH048						19							
12/11/2012	DH048						28							
2/7/2012	DH049						14							
4/17/2012	DH049						0							
6/12/2012	DH049						0							
8/8/2012	DH049						12							
10/23/2012	DH049						15							
12/11/2012	DH049						22							
2/7/2012	DH050						0							
4/17/2012	DH050						0							
6/12/2012	DH050						0							
8/8/2012	DH050						8							
10/23/2012	DH050						12							
12/11/2012	DH050						15							
2/7/2012	DH051						2							
4/17/2012	DH051						0							
6/12/2012	DH051						0							
8/8/2012	DH051						8							
10/23/2012	DH051						15							
12/11/2012	DH051						15							
2/7/2012	DH052						5							
4/17/2012	DH052						0							
6/12/2012	DH052						0							
8/8/2012	DH052						12							
10/23/2012	DH052						20							
12/11/2012	DH052						24							
2/7/2012	DH053						16							
4/17/2012	DH053						20							
6/12/2012	DH053						12							
8/8/2012	DH053						16							
10/23/2012	DH053						16							
12/11/2012	DH053						25							
2/7/2012	DH054						16							
4/17/2012	DH054						0							
6/12/2012	DH054						0							
8/8/2012	DH054						20							

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
10/23/2012	DH054						15							
12/11/2012	DH054						25							
2/7/2012	DH055						16							
4/17/2012	DH055						0							
6/12/2012	DH055						0							
8/8/2012	DH055						12							
10/23/2012	DH055						15							
12/11/2012	DH055						25							
2/7/2012	DH057						10							
4/17/2012	DH057						0							
6/12/2012	DH057						0							
8/8/2012	DH057						14							
10/23/2012	DH057						19							
12/11/2012	DH057						26							
2/7/2012	DH058						0							
4/17/2012	DH058						0							
6/12/2012	DH058						8							
8/8/2012	DH058						18							
10/23/2012	DH058						29							
12/11/2012	DH058						26							
2/7/2012	DH271						2							
4/17/2012	DH271						0							
6/12/2012	DH271						0							
8/8/2012	DH271						10							
10/23/2012	DH271						15							
12/11/2012	DH271						14							
2/7/2012	DH272						12							
4/17/2012	DH272						0							
6/12/2012	DH272						0							
8/8/2012	DH272						8							
10/23/2012	DH272						14							
12/11/2012	DH272						16							
2/15/2012	DH285	10.88	7.69		6.05		26.92	130		42540				
4/11/2012	DH285	13.09	8.22		10.12		28.15	110		43862				
6/6/2012	DH285	8.89	7.805		10.015		28.055	105		43727.5				
8/1/2012	DH285	8.46	8.21		14.5		27.97	140		43394				
11/26/2012	DH285	8.77	7.6		6.51		27.15	120		42800				
12/6/2012	DH285	10.68	7.59		6.32		21.94	80		35610				
2/15/2012	DH286	10.13	7.73		5.53		27.54	70		43498				
4/11/2012	DH286	13.45	8.29		10.48		27.76	60		43242				
6/6/2012	DH286	9.15	8.12		11.84		28.03	50		43595				
8/1/2012	DH286	10.77	8.62		20.9		27.51	90		42709				
11/26/2012	DH286	9.31	7.65		6.86		27.53	50		43300				
12/6/2012	DH286	11.34	7.63		6.2		21.33	80		34415				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
2/15/2012	DH287	9.91	7.67		6.15		28.08	170		44173				
4/11/2012	DH287	11.5	7.9		9.33		28.67	160		44780.5				
6/6/2012	DH287	8.77	7.76		10.2		27.72	140		43249				
8/1/2012	DH287	7.98	8.15		12.6		28.48	190		44173				
11/26/2012	DH287	8.53	7.62		7.22		27.91	180		43796				
12/6/2012	DH287	9.56	7.58		7.84		27.97	190		43483				
2/15/2012	DH288	10.01	7.59		6.4		29.01	100		45474				
4/11/2012	DH288	11.07	7.24		10.44		27.35	90		42775				
6/6/2012	DH288	8.41	7.69		10.03		29.33	60		45524				
8/1/2012	DH288	10.44	8.365		15.25		27.59	100		42840.5				
11/26/2012	DH288	9.52	7.64		6.75		27.06	80		42638				
12/6/2012	DH288	9.64	7.58		7.6		28.1	160		44030				
1/10/2012	SW001	9.42					28.37	110		444578				
2/1/2012	SW001	9.635					28.225	250		44361.5				
3/6/2012	SW001	9.74	7.05		6.53		27.94	200		43891				
4/4/2012	SW001	10.12	7.09		8.37		27.38	209		42674				
5/16/2012	SW001	12.11	8.08		15.04		27.98	230		43376			0.009	
6/27/2012	SW001	9.03	8.02		15.78		26.27	290		40967				
7/11/2012	SW001	9.85	8.12		18.23		25.68	280		40127				
8/9/2012	SW001	7.67	8.03		18.5		21.46	200		34072			0.009	
9/6/2012	SW001	9.04	7.93		17.2		26.68	250		41518				
10/9/2012	SW001	7.59	7.43		11.44		29.31	200		45400				
11/27/2012	SW001	7.36	7.48		7.655		28.39	280		44432			0.009	
1/10/2012	SW002	9.92					28.49	50		44711				
2/1/2012	SW002	10.195					27.28	150		42975.5				
3/6/2012	SW002	10.99	7.61		6.35		28.79	140		112.5				
4/4/2012	SW002	11.57	7.75		7.55		28.91	100		45179				
5/16/2012	SW002	14.355	8.57		16.04	8.7	27.305	50	1.52	42434	2100	0.09		0.44
6/27/2012	SW002	10.015	8		14.265		20.125	150		32201.5				
7/11/2012	SW002	12.27	8.4		16.29		26.27	150		40946				
8/9/2012	SW002	14.39	8.76		17.3	14	24.39	150	0.827	38304	1800	0.09		0.4
9/6/2012	SW002	12.025	8.27		15.63		26.22	150		40901				
10/9/2012	SW002	8.49	7.73		10.9		29.39	200		45543				
11/27/2012	SW002	7.87	7.53		8	0.27	28.98	220	2.14	45242	2400	0.18		0.21
1/25/2012	SW003	10.66					0.15			313				
2/29/2012	SW003	10.16	6.91		3.02	4.9	0.15		12.1	316	5.6	0.18		1.1
3/21/2012	SW003	8.85	6.14		5.36		0.18			380				
4/23/2012	SW003	6.31	5.8		12.73		0.17			338				
5/9/2012	SW003	4.86	6.78		12.115	15	0.27		3.52	560	24	0.09		1.1
6/21/2012	SW003	5.4	6.56		16.7		0.69			1351				
7/18/2012	SW003	4.94	6.96		20.46		2.15			4040				
8/28/2012	SW003	8.91	8.21		18.7	0.27	18.94		1.97	30433	1500	0.09		1.8
9/13/2012	SW003	7	7.83		14.89		25.38			39712				
10/16/2012	SW003	5.52	7.13		11.555		25.12			39456.5				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
11/14/2012	SW003	6.79	6.46		7.76	0.27	0.17		5.72	343	35	0.18		0.96
12/13/2012	SW003	8.14	7.3		5.66		0.13			278				
5/22/2012	SW004	12.5	4.16		6.23		0.02			39				
1/10/2012	SW006	9.87					27.015	90		42595				
2/1/2012	SW006	12.24					6.16	50		10934				
3/6/2012	SW006	11.65	7.58		5.57		16.26	60		27198				
4/4/2012	SW006	11.56	7.54		7.95		4.18	130		7504				
5/16/2012	SW006	11.07	8.42		16.17	2.8	10.55	70	4.41	17207	750	0.09		0.2
6/27/2012	SW006	9.27	8.12		14.54		22.43	220		35534				
7/11/2012	SW006	10.06	7.64		17.07		1.48	30		2858				
8/9/2012	SW006	9.78	8.41		17.5	4	7.7	70	4.43	12763	560	0.09		0.17
9/6/2012	SW006	9.92	8.26		16.89		25.05	180		39327				
10/9/2012	SW006	12.15	8.14		11.7		28.22	150		43846				
11/27/2012	SW006	9.41	7.47		6.2	0.27	17.12	120	3.64	28122	830	0.18		0.23
1/31/2012	SW007	12.65					0.04			86				
2/7/2012	SW007	13.09					0.06			118				
3/20/2012	SW007	11.83	7.405		6.12		0.06			120				
4/17/2012	SW007	12.42	5.52		6.02		0.03			71				
5/29/2012	SW007	11.73	5.65		9.15		0.03			72				
6/12/2012	SW007	10.56	5.93666667		12.01		0.04			82				
7/12/2012	SW007	10.84	7.02		12.59		0.03			63				
8/8/2012	SW007	10.21	8.16		15.5		0.03			73.5				
9/21/2012	SW007	4.47	7.42		13.88		0.21			435				
10/26/2012	SW007	5.96	7.73		7.79		0.06			126				
11/28/2012	SW007	12.27	7.34		5.14		0.05			114				
12/11/2012	SW007	12.305	7.5		5.56		0.05			115				
1/25/2012	SW008	11.61					5.19			9373				
2/29/2012	SW008	11.32	7.57		3.2		0.3			619				
3/21/2012	SW008	8.76	7.22		7.53		0.73			1448				
4/23/2012	SW008	5.51	7.06		14.61		0.62			1238				
5/9/2012	SW008	5.24	7.44		14.27		1.57			3010				
6/21/2012	SW008	7.77	7.4		22.95		7.16			12471				
7/18/2012	SW008	1.61	7.36		23.77		12.64			21087				
8/28/2012	SW008	1.89	7.24		19.05		25.58			39986.5				
9/13/2012	SW008	8.58	7.22		17.18		28.67			44314				
10/16/2012	SW008	5.2	7.15		12.65		25.41			39851				
11/14/2012	SW008	6.925	6.815		7.685		0.34			695				
12/13/2012	SW008	8.7	7.49		5.95		0.99			1955				
1/25/2012	SW009	1.52					0.44			906				
2/29/2012	SW009	2.475	6.765		1.74	1.9	0.33		12.8	681.5	29	0.18		1
3/21/2012	SW009	0.44	6.86		7.16		0.35			723				
4/23/2012	SW009	12.18	6.835		13.255		0.18			375				
5/9/2012	SW009	0.28	7.08		12.48	64	0.4		15.4	808	1	0.09		1.6
6/21/2012	SW009	2.29	6.74		13.9		0.14			289				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/25/2012	SW010	9.84					0.46			936				
2/29/2012	SW010	10.95	6.87		2.04		0.34			702				
3/21/2012	SW010	9.95	7.05		7.07		0.17			346				
4/23/2012	SW010	9.59	7.13		17.2		0.45			918				
5/9/2012	SW010	10.97	7.18		16.2		0.55			1105				
11/14/2012	SW010	4.34	6.66		8.05		0.31			637				
12/13/2012	SW010	8.88	7.4		5.59		0.14			295				
1/25/2012	SW011	14.4					0.06			114				
2/29/2012	SW011	13.95	7.15		2.65		0.06			134				
3/21/2012	SW011	12.81	6.8		5.67		0.06			133				
4/23/2012	SW011	11.47	7.18		11.67		0.07			148				
5/9/2012	SW011	11.8	7.62		10.89		0.08			168				
6/21/2012	SW011	10.1	7.4		13.74		0.09			189				
7/18/2012	SW011	7.72	7.35		15.68		0.11			228				
10/16/2012	SW011	6.35	7.15		11.14		0.14			283				
11/14/2012	SW011	11.69	6.86		8.23		0.06			129				
12/13/2012	SW011	12.01	7.38		5.96		0.06			121				
1/25/2012	SW012	10.42					0.11			222				
2/29/2012	SW012	11.69	7.01		2.87		0.09			200				
3/21/2012	SW012	11.14	6.77		6.525		0.1			200.5				
4/23/2012	SW012	6.11	6.95		13.2		0.1			203				
5/9/2012	SW012	5.39	7.18		12.98		0.11			239				
6/21/2012	SW012	19.64	7.705		17.205		0.85			1672.5				
11/14/2012	SW012	6.7	6.14		7.83		0.09			183				
12/13/2012	SW012	8.21	7.19		6.14		0.09			186				
1/25/2012	SW013	9.55					0.31			634				
2/29/2012	SW013	13.75	7.03		1.79		0.24			501				
3/21/2012	SW013	14.39	7.42		8.6		0.24			490				
4/23/2012	SW013	3.03	6.8		14.02		0.36			727				
5/9/2012	SW013	1.4	6.89		14.14		0.44			884				
6/21/2012	SW013	1.4	7.03		17.61		0.55			1097				
11/14/2012	SW013	5.5	6.79		8.86		0.27			562				
12/13/2012	SW013	7.65	7.09		5.67		0.23			474.5				
1/25/2012	SW014	11.3					0.08			160				
2/29/2012	SW014	11.7	6.97	6.5	3.5		0.06			121				
3/21/2012	SW014	11.35	6.5		5.95		0.06			126				
4/23/2012	SW014	9.33	4.47		10.3		0.06			131				
5/9/2012	SW014	8.59	5.95		9.99		0.07			153				
6/21/2012	SW014	6.4	5.42		14.24		0.1			207				
7/18/2012	SW014	3.71	6.82		16.16		0.14			283				
10/16/2012	SW014	5.83	7.05		11.76		0.08			175				
11/14/2012	SW014	8.11	6.39		8.13		0.06			137				
12/13/2012	SW014	9.45	7.53		6.11		0.06			125				
1/13/2012	SW015	5.72					0.91			1819				

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Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
2/21/2012	SW015	8.59	6.73		6.8725	5.7	0.49		10.1	995	160	0.18		1.2
3/13/2012	SW015	9.62	6.77		4.74		0.29			606				
4/18/2012	SW015	10.11	7.09		12.86		0.45			904				
5/22/2012	SW015	7.95	7.14		15.17	0.27	0.4		4.12	820	140	0.09		0.92
6/13/2012	SW015	7.99	7.10		17.76		0.48			961				
7/23/2012	SW015	5.69	7.39		17.1		0.825			1628				
11/8/2012	SW015	2.20	6.44		7.95	0.66	0.44		10.4	886	180	0.18		2.3
12/14/2012	SW015	8.80	7.70		4.72		0.26			545				
1/13/2012	SW016	11.93					0.545			1098				
2/21/2012	SW016	11.12	6.73		7.26		0.07			149				
3/13/2012	SW016	9.85	6.66		5.7		0.18			388				
4/18/2012	SW016	20.56	7.18		12.04		0.43			863				
5/22/2012	SW016	6.76	7.10		14.44		0.41			824				
6/13/2012	SW016	1.98	6.79		15.45		0.6			1196				
11/8/2012	SW016	4.47	6.69		9.15		0.42			849				
12/14/2012	SW016	11.26	7.38		4.8		0.11			227				
1/13/2012	SW017	0.99					0.56			1142				
2/21/2012	SW017	10.02	6.74		7.07		0.33			685				
3/13/2012	SW017	9.59	6.73		5.93		0.34			689				
4/18/2012	SW017	4.07	6.64		10.64		0.92			1809				
5/22/2012	SW017	1.48	6.72		14.12		0.49			993				
6/13/2012	SW017	4.30	6.98		16.95		0.54			1085				
12/14/2012	SW017	7.22	7.11		4.87		0.44			905				
1/10/2012	SW019	9.61					28.34	90		44501				
2/1/2012	SW019	10.33					27.24	280		42970				
3/6/2012	SW019	10.23	7.35		5.95		27.96	200		44003				
4/4/2012	SW019	9.89	7.63		7.97		28.27	290		44198				
5/16/2012	SW019	12.24	8.21		13.88		27.68	200		42963				
6/27/2012	SW019	8.95	7.97		15.5		20.93	230		33323				
7/11/2012	SW019	9.37	12.16		12.155		25.55	230		39952				
8/9/2012	SW019	7.48	8.38		18.85		21.495	270		34183				
9/6/2012	SW019	8.83	7.99		16.51		25.76	200		40249				
10/9/2012	SW019	6.97	7.50		11.28		29.36	240		45477				
11/27/2012	SW019	7.60	7.43		7.52		28.76	290		44993				
1/10/2012	SW022	9.37					28.81	110		45129				
2/1/2012	SW022	10.13					28.63	90		44870				
3/6/2012	SW022	10.54	7.48		6.01		27.9	120		102				
4/4/2012	SW022	9.91	7.61		7.88		26.22	100		40672				
5/16/2012	SW022	9.13	8.24		17.15		28.88	40		44617				
6/27/2012	SW022	9.32	7.94		13.37		25.61	140		40115				
7/11/2012	SW022		8.10		14.02		25.9	125		40476				
8/9/2012	SW022	11.22	8.66		15.6		24.71	190		38775				
9/6/2012	SW022	11.18	8.25		16.1		25.25	150		39524				
10/9/2012	SW022	8.22	7.70		10.72		29.35	190		45495				

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Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
11/27/2012	SW022	8.28	7.48		7.33		28.84	210		45095				
1/10/2012	SW023	9.44					27.83	110		43755.5				
2/1/2012	SW023	11.67					16.93	110		27901				
3/6/2012	SW023	12.06	7.45		5.55		11.84	30		20055				
5/16/2012	SW023	10.67	8.42		15.72		16.44	120		26747				
6/27/2012	SW023	9.67	8.06		14.82		15	80		24586				
7/11/2012	SW023	9.86	7.76		16.62		1.19	30		2300				
8/9/2012	SW023	9.41	8.01		16.9		1.96	40		3682				
9/6/2012	SW023	9.25	8.05		15.61		25.7	220		40159				
10/9/2012	SW023	11.38	8.08		11.74		27.99	190		43514				
11/27/2012	SW023	11.42	7.56		4.81		8.91	90		15229				
1/10/2012	SW026	13.37					17.3			28353				
2/1/2012	SW026	9.79					6.94			12221				
3/6/2012	SW026	13	7.38		5.1		0.47			963				
4/4/2012	SW026	11.17	7.32		13.15		0.72			1444				
5/16/2012	SW026	3.52	7.05		24.3		4.08			7440				
11/27/2012	SW026	11.32	7.05		3.69		3.84			7063				
1/10/2012	SW027	5.41					4.54			8271				
2/1/2012	SW027	11.14					0.08			176				
3/6/2012	SW027	11.935	6.59		7.19		0.05			110.5				
4/4/2012	SW027	10.585	6.81		11.055		0.05			104				
5/16/2012	SW027	10.06	7.28		13.71		0.08			165				
6/27/2012	SW027	10.08	7.41		14.18		0.1			202				
7/11/2012	SW027	9.41	7.52		16.12		0.21			432				
11/27/2012	SW027	11.63	7.37		5.34		0.06			135				
1/10/2012	SW028	12.21					19.68			32088				
2/1/2012	SW028	11.24					2.46			4613				
3/6/2012	SW028	14.525	7.31		8.655		0.45			910.5				
4/4/2012	SW028	14.91	7.17		13.66		1.35			2588				
5/16/2012	SW028	16.595	8.975		21.545		25.76			40209				
11/27/2012	SW028	11.19	7.48		4.92		5.43			9718				
1/31/2012	SW029	11.77					0.06			121				
2/7/2012	SW029	12.88					0.06			120				
3/20/2012	SW029	12.12	5.1		5.41		0.05			98				
4/17/2012	SW029	11.85	4.19		7.71		0.05			98				
5/29/2012	SW029	9.92	1.34		10.7		0.06			118				
6/12/2012	SW029	9.68	1.51		11.88		0.06			121				
11/28/2012	SW029	14.03	4.41		4.58		0.05			105				
12/11/2012	SW029	15.45	4.385		6.09		0.05			98				
1/31/2012	SW030	12.97					0.79			1536				
2/7/2012	SW030	12.24					7.43			12967				
3/20/2012	SW030	10.23	7.74		7.42		24.6			39021				
4/17/2012	SW030	11.63	7.91		10.05		2.4			4566				
5/29/2012	SW030	10.78	8.12		14.06		1.25			2408				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
6/12/2012	SW030	10.945	8.115		14.975		2.11			3970				
7/12/2012	SW030	9.72	7.97		18.72		1.07			2090				
8/8/2012	SW030	10.38	8.455		17.45		1.79			3395.5				
9/21/2012	SW030	9.44	7.83		14.53		18.78			30241				
10/26/2012	SW030	9.63	7.45		8.28		17.85			29163				
11/28/2012	SW030	11.7	7.33		5.61		4.94			9046				
12/11/2012	SW030	12.23	7.72		5.88		7.92			13849				
1/31/2012	SW031	8.36					0.06			133				
2/7/2012	SW031	8.8					0.06			118				
3/20/2012	SW031	10.46	5.99		6.52		0.04			76				
4/17/2012	SW031	9.925	5.48		8.87		0.04			85.5				
5/29/2012	SW031	7.08	6.16		11.85		0.06			119				
6/12/2012	SW031	6.77	6.33		13.17		0.07			154				
11/28/2012	SW031	11.7	6.3		4.83		0.04			88				
12/11/2012	SW031	8.03	4.54		6		0.04			87				
1/31/2012	SW032	12.36					6.88			12543				
2/7/2012	SW032	12.39					7.38			12888				
3/20/2012	SW032	10.23	7.68		7.04		25.15			40033				
4/17/2012	SW032	12.27	7.48		8.16		2.81			5322				
5/29/2012	SW032	11.49	8.36		14.79		7.88			13595				
6/12/2012	SW032	13.57	8.97		15.88		2.97			5520				
7/12/2012	SW032	10.3	7.58		16.3		0.91			1785				
8/8/2012	SW032	9.87	8.06		17.6		5.72			10187				
9/21/2012	SW032	10.8	7.75		14.05		12.36			20622				
10/26/2012	SW032	10.53	7.67		8.13		15.51			25472				
11/28/2012	SW032	9.74	6.78		5.93		19.05			30987				
12/11/2012	SW032	11.49	7.38		6.25		14.65			24291				
1/31/2012	SW033	6.47					0.06			129.5				
2/7/2012	SW033	7.86					0.06			131				
3/20/2012	SW033	8.085	5.8		6.46		0.04			88				
4/17/2012	SW033	8.43	5.71		8.68		0.05			105				
6/12/2012	SW033	5.165	6.535		14.285		0.11			224.5				
11/28/2012	SW033	6.37	6.14		5.06		0.05			112.5				
12/11/2012	SW033	6.26	5.01		6.04		0.05			103				
1/31/2012	SW034	12.35					6.9			12222				
2/7/2012	SW034	12.51					16.81			27781				
3/20/2012	SW034	10.23	7.71		6.95		24.7			39326				
4/17/2012	SW034	12.15	7.36		8.22		1.45			2772				
5/29/2012	SW034	11.95	8.54		14.66		7.4			12825				
6/12/2012	SW034	13.14	8.64		14.71		3.07			5662				
7/12/2012	SW034	9.755	7.76		17.435		0.97			1881				
8/8/2012	SW034	9.81	8.14		17		5.26			9420				
9/21/2012	SW034	9.855	7.78		13.895		11.98			20014.5				
10/26/2012	SW034	10.81	7.65		7.88		13.02			21772				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
11/28/2012	SW034	9.79	7.15		6.06		18.7			30383				
12/11/2012	SW034	11.47	7.5		6.24		14.74			24470				
1/31/2012	SW035	7.2					0.33			672				
2/7/2012	SW035	7.84					0.38			778				
3/20/2012	SW035	8.5	6.6		6.99		0.37			748				
4/17/2012	SW035	9.965	6.095		8.59		0.06			136				
1/31/2012	SW036	12.51					5.21			9348				
2/7/2012	SW036	13.2					12			20169				
3/20/2012	SW036	11.26	7.85		7.28		24.07			38286				
4/17/2012	SW036	12.4	7.64		8.18		2.77			5150				
5/29/2012	SW036	10.375	8.03		14.48		6.535			11447.5				
6/12/2012	SW036	11.72	8.22		13.98		3.13			5770				
7/12/2012	SW036	10.3	8.07		17.7		2.03			3798				
8/8/2012	SW036	9.87	8.15		16.8		4.93			8763				
9/21/2012	SW036	9.64	7.77		14		13.77			22734				
10/26/2012	SW036	10.79	7.655		7.635		12.55			21030				
11/28/2012	SW036	12.56	7.52		4.81		13.69			22997				
12/11/2012	SW036	11.555	7.625		6.16		13.74			22933.5				
2/7/2012	SW037	9.4					0.21			428				
1/31/2012	SW038	12.72					3.72			8376				
2/7/2012	SW038	14.32					9.02			15831				
3/20/2012	SW038	11.62	7.88		6.77		23.87			38113				
4/17/2012	SW038	12.39	7.99		8.12		6.04			10720				
5/29/2012	SW038	10.95	8.17		14.32		7.38			12783				
6/12/2012	SW038	10.95	8.03		13.85		3.71			6742				
7/12/2012	SW038	10.36	8.04		17.12		2.44			4511				
8/8/2012	SW038	9.87	8.22		16.7		6.8			11842				
9/21/2012	SW038	9.58	7.78		14.02		14.33			23565				
10/26/2012	SW038	10.61	7.63		8.01		14.64			24240				
11/28/2012	SW038	10.86	7.48		4.97		15.44			25764				
12/11/2012	SW038	11.87	7.65		6.27		15.57			25747				
1/31/2012	SW039	11.99					11.93			18674				
2/7/2012	SW039	12.34					18.69			30269				
3/20/2012	SW039	10.39	7.76		6.53		27.23			42913				
4/17/2012	SW039	13.81	8		8.95		28.32			44200				
5/29/2012	SW039	10.66	8.11		13.46		13.8			22790				
6/12/2012	SW039	14.73	8.31		12.23		27.81			43320				
7/12/2012	SW039	14.1	8.09		16		25.02			39190				
8/8/2012	SW039	9.47	8.11		16.1		15.73			25544				
9/21/2012	SW039	8.57	7.6		13.57		24.32			38542				
10/26/2012	SW039	6.26	7.35		9.33		28.98			45092				
11/28/2012	SW039	8.51	7.3		7.61		25.36			39647				
12/11/2012	SW039	9.81	7.49		7.25		24.56			39029				
1/13/2012	SW051	10.32					27.91			44867				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/25/2012	SW051	11.69					19.53			31797				
2/21/2012	SW051	10.59	7.18		6.06		11.04			18768				
2/29/2012	SW051	11.58	7.57		3.52		25.16			4352				
3/13/2012	SW051	11.1	7.17		4.64		11.05			18847				
3/21/2012	SW051	11.68	6.77		6.46		7.51			13112				
4/18/2012	SW051	6.69	7.54		10.48		14.34			23671				
4/23/2012	SW051	8.54	7.34		17.32		6.71			11705				
5/9/2012	SW051	8.46	7.88		15.76		17.12			27678				
5/22/2012	SW051	8.06	7.94		15.27		21.73			34535				
6/13/2012	SW051	10.9	8.13		18.84		22.6			35703				
6/21/2012	SW051	6.63	8.15		22.95		31.51			34250				
7/18/2012	SW051	4.22	7.64		22.32		20.58			32874				
7/23/2012	SW051	7.55	7.81		16.44		24.82			38919				
8/16/2012	SW051	2.9	7.72		25.5		24.31			38187				
8/28/2012	SW051	4.93	6.94		18.3		27.21			42275				
9/13/2012	SW051	8.13	7.33		16.89		27.36			42488				
9/14/2012	SW051	4.98	7.71		18.26		27.43			42585				
10/16/2012	SW051	7.67	7.38		12.66		27.98			43464				
10/19/2012	SW051	8.17	7.51		11.49		28.94			44878				
11/8/2012	SW051	8.66	6.78		6.94		21.34			34256				
11/14/2012	SW051	7.86	6.68		8.15		13.58			22590				
12/13/2012	SW051	9.2	6.43		6.29		16.93			27761				
12/14/2012	SW051	9.95	6.82		5.35		18.51			30279				
1/13/2012	SW052	14.01					27.65			44894				
2/21/2012	SW052	10.86	7.73		6.21		25.41			40344				
3/13/2012	SW052	11.43	7.51		4.31		25.81			41151				
4/18/2012	SW052	10.89	8.1		10.65		27.65			42112				
5/22/2012	SW052	9.53	7.96		14.47		28.22			43742				
6/13/2012	SW052	11.06	8.11		17.31		28.85			44560				
7/23/2012	SW052	8.69	7.72		15.8		27.77			43074				
8/16/2012	SW052	7.64	8.31		22.7		27.34			42529				
9/14/2012	SW052	8.335	7.99		16.07		28.84			44560				
10/19/2012	SW052	9.565	7.84		12.145		28.17			43757				
11/8/2012	SW052	11.28	7.79		8.57		26.1			41070				
12/14/2012	SW052	11.35	7.52		4.91		25.99			41341				
1/25/2012	SW053	11.88					10.115			17417.5				
2/29/2012	SW053	12.18	7.11		2.89		5.78			10213				
3/21/2012	SW053	9.34	6.89		7.3		2.98			5499.5				
4/23/2012	SW053	8.32	6.99		15.39		4.88			8703				
5/9/2012	SW053	8.01	7.29		16.23		13.94			23051				
6/21/2012	SW053	6.38	8.02		22.41		23.87			37605				
7/18/2012	SW053	2.56	7.485		21.54		18.775			30231				
8/28/2012	SW053	5.04	7.75		19		26.64			41472				
9/13/2012	SW053	5.53	7.72		14.96		27.31			42428				
10/16/2012	SW053	7.11	7.27		12.29		27.24			42447				
11/14/2012	SW053	7.16	6.52		8.25		3.04			5607				
12/13/2012	SW053	8.625	7.475		7.155		27.815			43664				
1/13/2012	SW055	7.68					9.36			16360				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
2/21/2012	SW055	9.83	6.67		6.3		4.35			7881				
3/13/2012	SW055	10.14	6.2		4.39		3.31			6123				
4/18/2012	SW055	7.38	7.02		9.62		15.98			26182				
5/22/2012	SW055	6.07	6.93		13.78		19.55			31365				
6/13/2012	SW055	4.22	6.98		17.21		22.36			35387				
7/23/2012	SW055	5.69	7		16.22		22.4			35458				
8/16/2012	SW055	3.085	7.52		20.8		24.42			38356				
9/14/2012	SW055	6.55	7.41		16.11		26.56			41375				
10/19/2012	SW055	11.87	7.24		13.56		27.59			42897				
11/8/2012	SW055	4.97	6.37		8		8.59			14851				
12/14/2012	SW055	5.75	6.57		6.06		3.2			5902				
2/21/2012	SW056	10.59	7.31		6.13		1.56			3003				
3/13/2012	SW056	10.63	7.46		4.33		0.67			1347				
4/18/2012	SW056	10.37	7.27		11.68		5.51			9752				
5/22/2012	SW056	10.52	7.68		14.72		18.93			30000				
6/13/2012	SW056	7.895	7.34		18.175		11.475			19243				
7/23/2012	SW056	10.32	7.71		15.88		24.11			37681				
8/16/2012	SW056	9	8		22.9		27.6			42846				
9/14/2012	SW056	10.95	7.83		17.22		28.36			43866				
10/19/2012	SW056	6.82	7.15		13.22		27.27			42449				
11/8/2012	SW056	4.29	7.1		8.79		4.72			8486				
12/14/2012	SW056	7.79	7.55		4.99		0.77			1542				
1/13/2012	SW059	8.24					1			1985				
2/21/2012	SW059	8.16	6.64		5.96		0.44			901				
3/13/2012	SW059	9.54	6.87		4.76		0.24			504				
4/18/2012	SW059	11.145	7.08		10.655		0.56			1124.5				
5/22/2012	SW059	5.25	6.9		13.18		0.78			1527				
6/13/2012	SW059	6.27	7.07		15.62		0.72			1425				
10/19/2012	SW059	7.8	6.98		12.35		1.82			1762				
11/8/2012	SW059	3.43	6.83		8.15		0.47			945				
12/14/2012	SW059	7.815	7.235		5.19		0.28			585				
1/13/2012	SW072	2.91					0.06			135				
2/21/2012	SW072	8.09	6.68		6.07		0.1			202				
3/13/2012	SW072	8.38	6.6		5.11		0.05			114				
4/18/2012	SW072	4.63	6.63		10.95		0.12			250				
5/22/2012	SW072	8.11	6.355		12.13		0.05			101.5				
6/13/2012	SW072	4.78	6.88		19.88		0.1			209				
7/23/2012	SW072	1.84	6.69		17.04		0.08			170				
8/16/2012	SW072	0.27	7.2		21.1		0.14			292				
10/19/2012	SW072	4.2	6.87		11.86		0.16			339				
11/8/2012	SW072	0.44	6.86		9.21		0.06			134				
12/14/2012	SW072	1.9	7.15		5.53		0.11			240				
1/13/2012	SW118	13.685					0.05			114				

Table A.3 2012 Selected Water Quality Results

Run Date	Site Number	Oxygen - Dissolved Field (mg/l)	pH - Field (pH units)	pH - Lab (pH units)	pH - Sample Temperature (deg C)	Pheophytin (ug/l)	Salinity (ppt)	Secchi Depth (cm)	Silicon (mg/l)	Specific Conductivity - Field (uS/cm)	Sulfate (mg/l)	Sulfide (mg/l)	Tin (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1/31/2012	SW118	12.77					0.04			87				
2/7/2012	SW118	13.34					0.05			116				
2/21/2012	SW118	12.1	6.89		5.63		0.06			122				
2/29/2012	SW118	13.14	6.92		3.60		0.06			119				
3/13/2012	SW118	12.7	6.72		4.49		0.05			102				
3/20/2012	SW118	12.35	7.13		5.90		0.06			118				
3/21/2012	SW118	12.55	6.94		8.48		0.06			121				
4/17/2012	SW118	12.41	5.26		5.85		0.03			71				
4/18/2012	SW118	12.39	5.08		6.93		0.04			89				
4/23/2012	SW118	12.15	5.34		8.29		0.03			71				
5/9/2012	SW118	11.88	6.63		9.08		0.04			78				
5/29/2012	SW118	11.94	6.58		9.07		0.03			72				
6/12/2012	SW118	10.84	6.71		11.59		0.04			80				
6/13/2012	SW118	11.82	4.64		9.59		0.03			69				
6/21/2012	SW118	11.22	6.81		10.88		0.03			69				
7/12/2012	SW118	10.69	6.50		12.32		0.03			63				
7/18/2012	SW118	10.405	4.35		12.54		0.03			58				
7/23/2012	SW118	11.07	5.85		11.05		0.04			76				
8/8/2012	SW118	10.52	7.96		15.30		0.03			73.2				
8/16/2012	SW118	9.67	8.80		18.30		0.04			87.5				
8/28/2012	SW118	9.84	7.93		15.80		0.05			103				
9/13/2012	SW118	12.39	7.15		13.12		0.05			116				
9/14/2012	SW118	10.97	7.20		13.80		0.06			120				
9/21/2012	SW118	10.51	7.43		13.68		0.05			124				
10/16/2012	SW118	11.44	7.22		10.27		0.03			66				
10/19/2012	SW118	11.16	7.12		9.84		0.03			62				
10/26/2012	SW118	12.12	7.44		7.66		0.05			115				
11/8/2012	SW118	12.38	7.46		6.68		0.05			104				
11/14/2012	SW118	12.16	7.18		7.32		0.05			101				
11/28/2012	SW118	12.365	7.14		5.05		0.05			111				
12/11/2012	SW118	12.21	7.28		5.51		0.05			116				
12/13/2012	SW118	12.56	7.57		5.88		0.06			117				
12/14/2012	SW118	11.9	7.31		5.57		0.06			123				

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
2/15/2012	DH038							5.906	6.6			
4/11/2012	DH038							4.593	8.78			
6/6/2012	DH038							3.937	10.04			
8/1/2012	DH038							6.234	14.7			
11/26/2012	DH038							5.833	8.085			
12/6/2012	DH038							7.874	8.1			
2/15/2012	DH039							7.218	6.62			
4/11/2012	DH039							6.562	8.83			
6/6/2012	DH039							6.234	9.89			
8/1/2012	DH039							7.874	12.8			
11/26/2012	DH039							7.333	7.91			
12/6/2012	DH039							9.843	8.18			
2/15/2012	DH040							6.234	6.79			
4/11/2012	DH040							6.234	8.41			
6/6/2012	DH040							4.593	9.95			
8/1/2012	DH040							7.218	12.6			
11/26/2012	DH040							6.667	8.16			
12/6/2012	DH040							9.514	8.36			
2/15/2012	DH041							5.577	6.78			
4/11/2012	DH041							5.249	8.43			
6/6/2012	DH041							3.609	9.75			
8/1/2012	DH041							5.906	18.3			
11/26/2012	DH041							6.567	7.86			
12/6/2012	DH041							8.53	8.26			
2/15/2012	DH042							5.906	6.65			
4/11/2012	DH042							5.906	10.52			
6/6/2012	DH042							3.609	11.69			
8/1/2012	DH042							6.234	18.2			
11/26/2012	DH042							6.562	7.67			
12/6/2012	DH042							9.186	8			
2/15/2012	DH043							9.186	6.82			
4/11/2012	DH043							6.562	8.9			
6/6/2012	DH043							4.265	10.91			
8/1/2012	DH043							7.218	14.6			
11/26/2012	DH043							376.6405	8.455			
12/6/2012	DH043							10.827	8.12			
2/15/2012	DH044						1.81	1.25	7.61			
4/11/2012	DH044						3.52	1.25	13.74			
6/6/2012	DH044						9.14	1	15.33			
8/1/2012	DH044						3.68	0.5	23.4			
11/26/2012	DH044						2.08	1.25	5.52			
12/6/2012	DH044						1.8	1.25	6.68			
2/15/2012	DH045						0.995	1.25	6.705			
4/11/2012	DH045						6.12	1.25	12.14			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
6/6/2012	DH045						1.77	1.25	15.63			
8/1/2012	DH045						2.49	0.75	22.1			
11/26/2012	DH045						9.48	1.5	5.5			
12/6/2012	DH045						1.545	1	6.715			
2/7/2012	DH048								7			
4/17/2012	DH048								10			
6/12/2012	DH048								14			
8/8/2012	DH048								16			
10/23/2012	DH048								9			
12/11/2012	DH048								7			
2/7/2012	DH049								5			
4/17/2012	DH049								9			
6/12/2012	DH049								15			
8/8/2012	DH049								19			
10/23/2012	DH049								9			
12/11/2012	DH049								7			
2/7/2012	DH050								5			
4/17/2012	DH050								9			
6/12/2012	DH050								14			
8/8/2012	DH050								19			
10/23/2012	DH050								9			
12/11/2012	DH050								7			
2/7/2012	DH051								5			
4/17/2012	DH051								9			
6/12/2012	DH051								14			
8/8/2012	DH051								19			
10/23/2012	DH051								9			
12/11/2012	DH051								7			
2/7/2012	DH052								5			
4/17/2012	DH052								9			
6/12/2012	DH052								15			
8/8/2012	DH052								19			
10/23/2012	DH052								9			
12/11/2012	DH052								7			
2/7/2012	DH053								5			
4/17/2012	DH053								9			
6/12/2012	DH053								15			
8/8/2012	DH053								18			
10/23/2012	DH053								9			
12/11/2012	DH053								7			
2/7/2012	DH054								5			
4/17/2012	DH054								9			
6/12/2012	DH054								15			
8/8/2012	DH054								19			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
10/23/2012	DH054								9			
12/11/2012	DH054								7			
2/7/2012	DH055								6			
4/17/2012	DH055								9			
6/12/2012	DH055								15			
8/8/2012	DH055								19			
10/23/2012	DH055								9			
12/11/2012	DH055								7			
2/7/2012	DH057								5			
4/17/2012	DH057								9			
6/12/2012	DH057								15			
8/8/2012	DH057								19			
10/23/2012	DH057								9			
12/11/2012	DH057								7			
2/7/2012	DH058								5			
4/17/2012	DH058								10			
6/12/2012	DH058								15			
8/8/2012	DH058								19			
10/23/2012	DH058								11			
12/11/2012	DH058								7			
2/7/2012	DH271								5			
4/17/2012	DH271								10			
6/12/2012	DH271								15			
8/8/2012	DH271								19			
10/23/2012	DH271								10			
12/11/2012	DH271								7			
2/7/2012	DH272								5			
4/17/2012	DH272								9			
6/12/2012	DH272								15			
8/8/2012	DH272								19			
10/23/2012	DH272								9			
12/11/2012	DH272								7			
2/15/2012	DH285							4.265	6.05			
4/11/2012	DH285							3.609	10.11			
6/6/2012	DH285							3.445	10.015			
8/1/2012	DH285							4.593	14.5			
11/26/2012	DH285							4	6.51			
12/6/2012	DH285							6.234	6.34			
2/15/2012	DH286							2.297	5.53			
4/11/2012	DH286							1.969	10.5			
6/6/2012	DH286							1.64	11.84			
8/1/2012	DH286							2.953	20.7			
11/26/2012	DH286							1.667	6.85			
12/6/2012	DH286							3.609	6.2			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
2/15/2012	DH287							5.577	6.15			
4/11/2012	DH287							5.249	9.385			
6/6/2012	DH287							4.593	10.19			
8/1/2012	DH287							6.234	12.6			
11/26/2012	DH287							6	7.23			
12/6/2012	DH287							6.562	7.84			
2/15/2012	DH288							3.281	6.4			
4/11/2012	DH288							2.953	10.45			
6/6/2012	DH288							1.969	10.03			
8/1/2012	DH288							3.281	15.2			
11/26/2012	DH288							2.667	6.75			
12/6/2012	DH288							5.249	7.6			
1/10/2012	SW001							12.467	6.26			
2/1/2012	SW001							9.843	6.345			
3/6/2012	SW001							11.155	6.53			
4/4/2012	SW001							9.843	8.34			
5/16/2012	SW001							8.202	15.11	6.8		0.145
6/27/2012	SW001							12.139	15.78			
7/11/2012	SW001							10.663	18.23			
8/9/2012	SW001							12.795	18.6	9.3		0.053
9/6/2012	SW001							12.303	17.19			
10/9/2012	SW001							13.123	11.44			
11/27/2012	SW001							12.139	7.645	8.1		0.034
1/10/2012	SW002							4.593	6.48			
2/1/2012	SW002							4.921	6.54			
3/6/2012	SW002							4.593	6.35			
4/4/2012	SW002							3.281	7.59			
5/16/2012	SW002		2.31	0.14	13	2.1		1.64	15.78	6.2		
6/27/2012	SW002							4.921	14.265			
7/11/2012	SW002							4.921	16.29			
8/9/2012	SW002		1.97	0.11	8.9	2.2		4.921	17.3	8.4		
9/6/2012	SW002							4.921	15.63			
10/9/2012	SW002							6.562	10.9			
11/27/2012	SW002		0.953	0.16	9.9	2.8		7.218	8.02	9		
1/25/2012	SW003						77.5	2	3.09			
2/29/2012	SW003		10.7	0.28	54	6.4	104	2	3.02	6.9		
3/21/2012	SW003						241	1	5.36			
4/23/2012	SW003						13.7	2	17.73			
5/9/2012	SW003		20	0.4	6.6	3.9	10.85	3	12.115	11.6		
6/21/2012	SW003						12.6	2.5	16.7			
7/18/2012	SW003						11.8	2	20.46			
8/28/2012	SW003		15.4	0.31	8.6	2.4	5.75	2	18.7	8.6		
9/13/2012	SW003						4.71	2	14.89			
10/16/2012	SW003						5.51	2.25	11.53			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
11/14/2012	SW003		11.5	0.27	5.3	2.1	11.5	4	7.76	6.5		
12/13/2012	SW003						15.7	3	5.66			
5/22/2012	SW004						767	3	6.25			
1/10/2012	SW006							6.89	6.615			
2/1/2012	SW006							12.467	6.14			
3/6/2012	SW006							8.53	5.57			
4/4/2012	SW006							6.89	7.95			
5/16/2012	SW006		1.52	0.1	17	1.2		13.123	16.27	9.6		
6/27/2012	SW006							9.514	14.54			
7/11/2012	SW006							6.562	17.06			
8/9/2012	SW006		1.31	0.09	14	1.3		13.123	17.5	9		
9/6/2012	SW006							6.89	16.89			
10/9/2012	SW006							9.514	11.7			
11/27/2012	SW006		2.09	0.12	3.8	1.4		9.186	6.27	7		
1/31/2012	SW007						42.45	4	4.93			
2/7/2012	SW007						7.9	2.5	4.64			
3/20/2012	SW007						8.17	2	6.12			
4/17/2012	SW007						76.1	2	6.02			
5/29/2012	SW007						32.2	4	9.15			
6/12/2012	SW007						17.2	3	12.05			
7/12/2012	SW007						75.1	3	12.59			
8/8/2012	SW007						32.9	2.25	15.5			
9/21/2012	SW007						5.75	1	13.88			
10/26/2012	SW007						9.18	0.833	7.79			
11/28/2012	SW007						10	2	5.14			
12/11/2012	SW007						10.85	4	5.56			
1/25/2012	SW008						37.9	0.917	3.56			
2/29/2012	SW008						29.8	0.5	3.19			
3/21/2012	SW008						31	1	7.53			
4/23/2012	SW008						18.2	1	14.61			
5/9/2012	SW008						42.6	0.333	14.27			
6/21/2012	SW008						19.2	1.25	22.98			
7/18/2012	SW008						18.4	0.5	23.77			
8/28/2012	SW008						12.7	0.667	19.05			
9/13/2012	SW008						11.2	1.25	17.14			
10/16/2012	SW008						16	1	12.65			
11/14/2012	SW008						13.3	1.167	7.685			
12/13/2012	SW008						19	1.25	5.95			
1/25/2012	SW009						32.2	2	3.64			
2/29/2012	SW009		37.9	0.3	61	18	39.75	2.5	1.74	7.3		
3/21/2012	SW009						55	2	7.16			
4/23/2012	SW009						33.85	1.5	13.255			
5/9/2012	SW009		23	0.82	160	49	53	1.5	12.48	16.5		
6/21/2012	SW009						24.9	2	14.5			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/25/2012	SW010						230	2	3.83			
2/29/2012	SW010						7.61	2	2.04			
3/21/2012	SW010						409	4	7.07			
4/23/2012	SW010						15.7	5	17.2			
5/9/2012	SW010						16	4	16.2			
11/14/2012	SW010						25.4	3.5	8.05			
12/13/2012	SW010						10.8	3	5.59			
1/25/2012	SW011						16.8	0.458	3.22			
2/29/2012	SW011						7.61	0.5	2.67			
3/21/2012	SW011						6.5	0.667	5.67			
4/23/2012	SW011						4.75	0.417	11.67			
5/9/2012	SW011						3.73	0.667	10.89			
6/21/2012	SW011						5.54	0.667	13.76			
7/18/2012	SW011						7.05	0.583	15.68			
10/16/2012	SW011						20.5	1.5	11.14			
11/14/2012	SW011						7.65	1	8.23			
12/13/2012	SW011						6.77	0.667	5.96			
1/25/2012	SW012						4.57	2.75	4.21			
2/29/2012	SW012						7.08	2	2.87			
3/21/2012	SW012						2.955	2.5	6.525			
4/23/2012	SW012						3.94	2.5	13.2			
5/9/2012	SW012						3.29	1	12.98			
6/21/2012	SW012						16.3	0.5	16.805			
11/14/2012	SW012						2.8	3	7.83			
12/13/2012	SW012						3.38	2.5	6.14			
1/25/2012	SW013						78.7	5	4.02			
2/29/2012	SW013						10.5	4.5	1.79			
3/21/2012	SW013						64.4	2.5	8.6			
4/23/2012	SW013						9.16	3.5	14.02			
5/9/2012	SW013						18.5	3.5	14.14			
6/21/2012	SW013						18.7	3.5	17.56			
11/14/2012	SW013						9.4	3	8.86			
12/13/2012	SW013						19.35	4	5.67			
1/25/2012	SW014						18.3	1.25	3.63			
2/29/2012	SW014						28.9	1.5	3.5		6.4	0.029
3/21/2012	SW014						16.9	1.5	5.95			
4/23/2012	SW014						11.5	1.25	10.3			
5/9/2012	SW014						9.04	1	9.99	12.5		0.0135
6/21/2012	SW014						6.84	1	14.24			
7/18/2012	SW014						13.1	1	16.16			
10/16/2012	SW014						16.5	1.25	11.75			
11/14/2012	SW014						11.19	1.25	8.13	7.2		0.029
12/13/2012	SW014						12.3	1.5	6.11			
1/13/2012	SW015						35.8	4	2.38			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
2/21/2012	SW015		10.6	0.25	22	4.8	38.96666667	5.5	6.13	9.1		
3/13/2012	SW015						97.1	0.375	4.74			
4/18/2012	SW015						13.6	5	12.86			
5/22/2012	SW015		13.6	0.15	8.4	7	9.5	5.5	15.17			
6/13/2012	SW015						15	3	17.76			
7/23/2012	SW015						11.55	4	17.1			
11/8/2012	SW015		16.3	0.44	12	4	12.8	2.5	7.95			
12/14/2012	SW015						17.6	5	4.72			
1/13/2012	SW016						3.83	0.583	3.02			
2/21/2012	SW016						438	3.5	7.26			
3/13/2012	SW016						33	2.083	5.7			
4/18/2012	SW016						9.78	2.5	12.04			
5/22/2012	SW016						25	2.5	14.44			
6/13/2012	SW016						61.1	1.25	15.39			
11/8/2012	SW016						4.03	1.5	9.15			
12/14/2012	SW016						27.8	3.25	4.8			
1/13/2012	SW017						32.7	1.167	2.79			
2/21/2012	SW017						46.9	2	7.07			
3/13/2012	SW017						17.9	1.5	5.93			
4/18/2012	SW017						9.18	1.25	10.64			
5/22/2012	SW017						19.6	0.833	14.12			
6/13/2012	SW017						31.5	0.5	16.7			
12/14/2012	SW017						11.1	3	4.88			
1/10/2012	SW019							14.764	6.49			
2/1/2012	SW019							12.467	6.27			
3/6/2012	SW019							14.108	5.95			
4/4/2012	SW019							3.8	7.97			
5/16/2012	SW019							10.499	13.88			
6/27/2012	SW019							14.108	15.5			
7/11/2012	SW019							13.944	16.245			
8/9/2012	SW019							14.928	18.85			
9/6/2012	SW019							14.764	16.51			
10/9/2012	SW019							15.748	11.28			
11/27/2012	SW019							17.06	7.55			
1/10/2012	SW022							3.609	6.83			
2/1/2012	SW022							2.953	6.81			
3/6/2012	SW022							3.937	6.01			
4/4/2012	SW022							3.281	7.88			
5/16/2012	SW022							1.312	17.15			
6/27/2012	SW022							4.593	13.37			
7/11/2012	SW022							4.101	14.02			
8/9/2012	SW022							6.234	15.6			
9/6/2012	SW022							4.921	16.1			
10/9/2012	SW022							6.234	10.72			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
11/27/2012	SW022							6.89	7.33			
1/10/2012	SW023							5.577	6.69			
2/1/2012	SW023							6.89	5.93			
3/6/2012	SW023							5.577	5.54			
5/16/2012	SW023							4.921	15.72			
6/27/2012	SW023							5.577	14.82			
7/11/2012	SW023							5.085	16.62			
8/9/2012	SW023							6.398	16.9			
9/6/2012	SW023							6.562	15.62			
10/9/2012	SW023							6.89	11.77			
11/27/2012	SW023							7.546	4.7			
1/10/2012	SW026						4.27	0.167	5.86			
2/1/2012	SW026						2.73	0.208	5.45			
3/6/2012	SW026						2.19	0.333	5.1			
4/4/2012	SW026						4.94	0.5	13.15			
5/16/2012	SW026						93.5	0.25	24.3			
11/27/2012	SW026						1.56	0.25	3.69			
1/10/2012	SW027						32.7	0.167	4.8			
2/1/2012	SW027						4.66	0.417	6.06			
3/6/2012	SW027						3.805	0.417	7.19			
4/4/2012	SW027						2.975	0.667	11.055			
5/16/2012	SW027						3.92	0.25	13.72			
6/27/2012	SW027						9.31	0.208	14.15			
7/11/2012	SW027						9.09	0.167	16.13			
11/27/2012	SW027						1.79	0.583	5.34			
1/10/2012	SW028						8.76	0.667	5.39			
2/1/2012	SW028						10.9	0.917	6.72			
3/6/2012	SW028						8.485	0.833	8.655			
4/4/2012	SW028						5.93	0.5	13.66			
5/16/2012	SW028						10.9	0.667	21.58			
11/27/2012	SW028						2.8	1	4.92			
1/31/2012	SW029						22	0.667	5.42			
2/7/2012	SW029						17.3	0.417	3.5			
3/20/2012	SW029						13.9	1	5.41			
4/17/2012	SW029						14.4	0.833	7.71			
5/29/2012	SW029						85.5	0.5	10.7			
6/12/2012	SW029						39.7	0.417	11.88			
11/28/2012	SW029						14.4	0.667	4.58			
12/11/2012	SW029						13	0.5	6.09			
1/31/2012	SW030						209	0.917	5.34			
2/7/2012	SW030						7.65	1.5	7			
3/20/2012	SW030						77.3	1.5	7.42			
4/17/2012	SW030						13.4	1	10.01			
41058	SW030						78.8	0.917	14.06			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
6/12/2012	SW030						27.7	0.833	14.925			
7/12/2012	SW030						115	1	18.72			
8/8/2012	SW030						81.45	1	17.45			
9/21/2012	SW030						18.1	1.5	14.53			
10/26/2012	SW030						9.65	1	8.29			
11/28/2012	SW030						6.61	1.5	5.74			
12/11/2012	SW030						36.4	1	5.88			
1/31/2012	SW031						23.3	0.125	5.8			
2/7/2012	SW031						24.55	0.167	4.595			
3/20/2012	SW031						11.6	1	6.52			
4/17/2012	SW031						13.4	0.333	8.875			
5/29/2012	SW031						13.6	0.5	11.85			
6/12/2012	SW031						15.3	0.833	13.17			
11/28/2012	SW031						18.4	0.5	4.82			
12/11/2012	SW031						15.4	0.25	6			
1/31/2012	SW032						57.6	1.5	5.78			
2/7/2012	SW032						4.89	2.5	6.63			
3/20/2012	SW032						40.6	2	7.04			
4/17/2012	SW032						7.83	2	8.16			
5/29/2012	SW032						17.5	2	14.79			
6/12/2012	SW032						13.6	1.5	15.88			
7/12/2012	SW032						80.3	2	16.3			
8/8/2012	SW032						26.4	2.5	17.6			
9/21/2012	SW032						14.7	1	14.05			
10/26/2012	SW032						40.4	1.25	8.15			
11/28/2012	SW032						4.1	1.5	5.93			
12/11/2012	SW032						34.4	2.25	6.25			
1/31/2012	SW033						41.75	0.167	5.54			
2/7/2012	SW033						39.7	0.167	4.775			
3/20/2012	SW033						18.2	0.1875	6.46			
4/17/2012	SW033						17.4	0.333	8.68			
6/12/2012	SW033						14.95	0.417	14.285			
11/28/2012	SW033						24.4	0.167	5.06			
12/11/2012	SW033						23.2	0.167	6.04			
1/31/2012	SW034						49.1	1.5	5.55			
2/7/2012	SW034						4.39	2.5	5.72			
3/20/2012	SW034						49	2	6.95			
4/17/2012	SW034						8.85	1.25	8.22			
5/29/2012	SW034						17.1	2	14.66			
6/12/2012	SW034						14.4	2	14.71			
7/12/2012	SW034						82.55	2	17.615			
8/8/2012	SW034						30.7	2.5	17			
9/21/2012	SW034						16.15	1.5	13.895			
10/26/2012	SW034						79.5	1	7.88			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
11/28/2012	SW034						6.13	1.25	6.08			
12/11/2012	SW034						68.4	2	6.24			
1/31/2012	SW035						34.1	0.167	5.83			
2/7/2012	SW035						29.1	0.125	4.66			
3/20/2012	SW035						42.5	0.167	6.99			
4/17/2012	SW035						7.24	0.333	8.59			
1/31/2012	SW036						53.6	2.5	5.51			
2/7/2012	SW036						4.21	2.5	5.28			
3/20/2012	SW036						23.7	2.5	7.28			
4/17/2012	SW036						9.4	2	8.22			
5/29/2012	SW036						18.35	1.5	14.48			
6/12/2012	SW036						11.1	1.5	13.97			
7/12/2012	SW036						41.3	1.5	17.7			
8/8/2012	SW036						27.7	2.5	16.8			
9/21/2012	SW036						12.6	2.25	14			
10/26/2012	SW036						41.2	1.5	7.65			
11/28/2012	SW036						4.22	2	4.66			
12/11/2012	SW036						23.45	2.25	6.16			
2/7/2012	SW037						1.19	0.208	7.23			
1/31/2012	SW038						52.9	2	5.5			
2/7/2012	SW038						4.68	2.5	5.25			
3/20/2012	SW038						4.84	2.5	6.77			
4/17/2012	SW038						6.97	1.5	8.12			
5/29/2012	SW038						15.9	2.25	14.32			
6/12/2012	SW038						9.53	1.5	13.87			
7/12/2012	SW038						49.1	2	17.12			
8/8/2012	SW038						23.9	2.5	16.7			
9/21/2012	SW038						13.6	2.25	14.02			
10/26/2012	SW038						31.7	2	8			
11/28/2012	SW038						4	1.5	4.94			
12/11/2012	SW038						22.9	2	6.27			
1/31/2012	SW039						33.1	2.5	5.48			
2/7/2012	SW039						2.59	2.5	6.67			
3/20/2012	SW039						6.59	2.5	6.53			
4/17/2012	SW039						3.99	1.5	8.95			
5/29/2012	SW039						11	1.75	13.46			
6/12/2012	SW039						5.97	1.75	12.23			
7/12/2012	SW039						11	1.75	16			
8/8/2012	SW039						19.3	2	16.1			
9/21/2012	SW039						7.49	2.25	13.57			
10/26/2012	SW039						6.86	1	9.33			
11/28/2012	SW039						2.92	1	7.63			
12/11/2012	SW039						13.1	2.25	7.25			
1/13/2012	SW051						4.88	0.917	1.28			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/25/2012	SW051						13.2	1.25	4.21			
2/21/2012	SW051						30.6	0.333	6.06			
2/29/2012	SW051						5.96	0.583	3.52			
3/13/2012	SW051						19.9	1.083	4.64			
3/21/2012	SW051						28.7	0.417	6.46			
4/18/2012	SW051						11.1	0.5	10.48			
4/23/2012	SW051						13	0.417	17.32			
5/9/2012	SW051						19.3	0.333	15.76			
5/22/2012	SW051						13.2	1	15.27			
6/13/2012	SW051						7.38	0.833	18.96			
6/21/2012	SW051						9.85	0.667	22.95			
7/18/2012	SW051						13.4	0.75	22.32			
7/23/2012	SW051						57.1	0.5	16.44			
8/16/2012	SW051						19.2	0.5	25.5			
8/28/2012	SW051						9.56	0.5	18.3			
9/13/2012	SW051						10.1	0.333	16.89			
9/14/2012	SW051						10.5	0.5	18.26			
10/16/2012	SW051						9.09	0.417	12.66			
10/19/2012	SW051						5.91	1.25	11.5			
11/8/2012	SW051						4.61	1	6.94			
11/14/2012	SW051						9.87	1.083	8.15			
12/13/2012	SW051						11.5	0.667	6.33			
12/14/2012	SW051						11.6	0.667	5.53			
1/13/2012	SW052						1.07	1.25	-0.16			
2/21/2012	SW052						4.03	0.583	6.21			
3/13/2012	SW052						7.51	1.5	4.31			
4/18/2012	SW052						2.44	1.167	10.65			
5/22/2012	SW052						4.23	1.25	14.47			
6/13/2012	SW052						1.66	1	17.37			
7/23/2012	SW052						19.4	1.5	15.8			
8/16/2012	SW052						1.91	1.083	22.7			
9/14/2012	SW052						1.985	0.833	16.07			
10/19/2012	SW052						6.585	1	12.145			
11/8/2012	SW052						0.72	0.833	8.58			
12/14/2012	SW052						1.34	0.833	4.92			
1/25/2012	SW053						26.1	1.2085	3.71			
2/29/2012	SW053						76.9	0.5	2.88			
3/21/2012	SW053						160.5	1.167	7.3			
4/23/2012	SW053						14	2	15.385			
5/9/2012	SW053						11	1.5	16.23			
6/21/2012	SW053						5.73	2	22.41			
7/18/2012	SW053						7.365	0.75	21.54			
8/28/2012	SW053						8.65	0.75	19			
9/13/2012	SW053						6.27	1.167	14.96			
10/16/2012	SW053						12.1	2	12.36			
11/14/2012	SW053						15.7	2	8.25			
12/13/2012	SW053						6.935	1.5	7.14			
1/13/2012	SW055						18.4	1.083	1.12			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
2/21/2012	SW055						20.8	2	6.3			
3/13/2012	SW055						16.6	4	4.39			
4/18/2012	SW055						7.53	1.167	9.62			
5/22/2012	SW055						7.5	1.5	13.78			
6/13/2012	SW055						4.71	1	17.21			
7/23/2012	SW055						6.64	1	16.22			
8/16/2012	SW055						6.57	1	20.8			
9/14/2012	SW055						3.71	1	16.11			
10/19/2012	SW055						22.8	1.5	13.56			
11/8/2012	SW055						18.8	1.25	8.05			
12/14/2012	SW055						31.8	2	6.06			
2/21/2012	SW056						22	2	6.13			
3/13/2012	SW056						37.3	3	4.38			
4/18/2012	SW056						12.9	0.583	11.68			
5/22/2012	SW056						7.19	1	14.72			
6/13/2012	SW056						15.2	0.667	18.17			
7/23/2012	SW056						6.83	1	15.88			
8/16/2012	SW056						13.6	1.167	22.9			
9/14/2012	SW056						13.7	0.5	17.22			
10/19/2012	SW056						7.51	1	13.22			
11/8/2012	SW056						13.3	1.5	8.74			
12/14/2012	SW056						13.8	2.5	4.92			
1/13/2012	SW059						16.4	2	1.8			
2/21/2012	SW059						27.5	4.5	5.9			
3/13/2012	SW059						48.4	3.5	4.76			
4/18/2012	SW059						12.15	2	10.655			
5/22/2012	SW059						12.5	2	13.18			
6/13/2012	SW059						16	1.5	15.62			
10/19/2012	SW059						7.52	3	12.13			
11/8/2012	SW059						9.395	3.5	8.15			
12/14/2012	SW059						15.5	3.5	5.195			
1/13/2012	SW072						14.2	1.25	2.93			
2/21/2012	SW072						9.32	0.917	6.07			
3/13/2012	SW072						13.05	1.25	5.11			
4/18/2012	SW072						3.35	5.5	10.94			
5/22/2012	SW072						18.05	2.5	12.13			
6/13/2012	SW072						7.19	1	19.92			
7/23/2012	SW072						11.6	2	17.04			
8/16/2012	SW072						46.9	2	21.1			
10/19/2012	SW072						12.3	2	11.91			
11/8/2012	SW072						14.2	2	9.2			
12/14/2012	SW072						12.8	2.5	5.53			
1/13/2012	SW118						7.515	0.5	2.57			

Table A.4 2012 Selected Water Quality Results

Run Date	Site Number	Total Nitrogen (mg/l)	Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)	Total Suspended Solids (mg/l)	Total Volatile Suspended Solids (mg/l)	Turbidity (NTU)	Water Depth (ft)	Water Level (VG) (ft)	Water Temperature - In Situ (deg C)	Water Temperature - pH Lab (deg C)	Zinc (mg/l)
1/31/2012	SW118						37.8	0.5	4.91			
2/7/2012	SW118						8.1	0.5	4.2			
2/21/2012	SW118						12.5	0.5	5.63			
2/29/2012	SW118						11.2	1	3.6			
3/13/2012	SW118						29.1	1	4.485			
3/20/2012	SW118						9.58	2	5.9			
3/21/2012	SW118						8.67	0.583	8.48			
4/17/2012	SW118						81.2	1	5.85			
4/18/2012	SW118						20.1	1.333	6.93			
4/23/2012	SW118						56.8	1.5	8.24			
5/9/2012	SW118						22.3	1	9.085			
5/29/2012	SW118						30.8	1.25	9.07			
6/12/2012	SW118						18.3	0.833	11.59			
6/13/2012	SW118						30.8	1.5	9.59			
6/21/2012	SW118						64.3	1	10.88			
7/12/2012	SW118						76.7	1.25	12.32			
7/18/2012	SW118						148.5	1	12.535			
7/23/2012	SW118						35.3	0.5	11.175			
8/8/2012	SW118						45.1	0.5	15.3			
8/16/2012	SW118						18.4	0.667	18.3			
8/28/2012	SW118						9.02	0.5	15.8			
9/13/2012	SW118						7.15	0.667	13.115			
9/14/2012	SW118						7.58	1	13.8			
9/21/2012	SW118						10.8	1	13.68			
10/16/2012	SW118						432	0.5	10.3			
10/19/2012	SW118							1	9.84			
10/26/2012	SW118						5.99	1.5	7.66			
11/8/2012	SW118						25	0.33	6.68			
11/14/2012	SW118						24.8	1	7.32			
11/28/2012	SW118						12.6	1	5.05			
12/11/2012	SW118						12.7	1	5.51			
12/13/2012	SW118						9.37	0.5	5.88			
12/14/2012	SW118						9.64	0.833	5.56			